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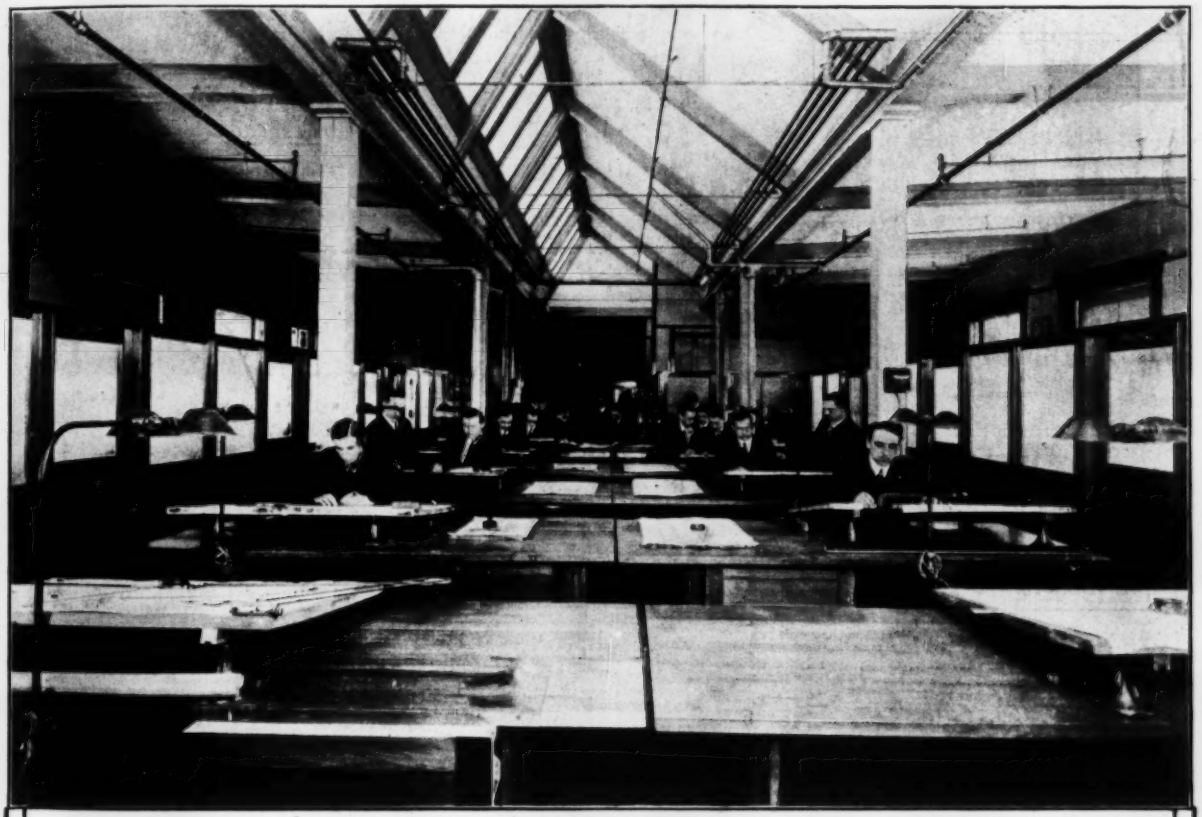

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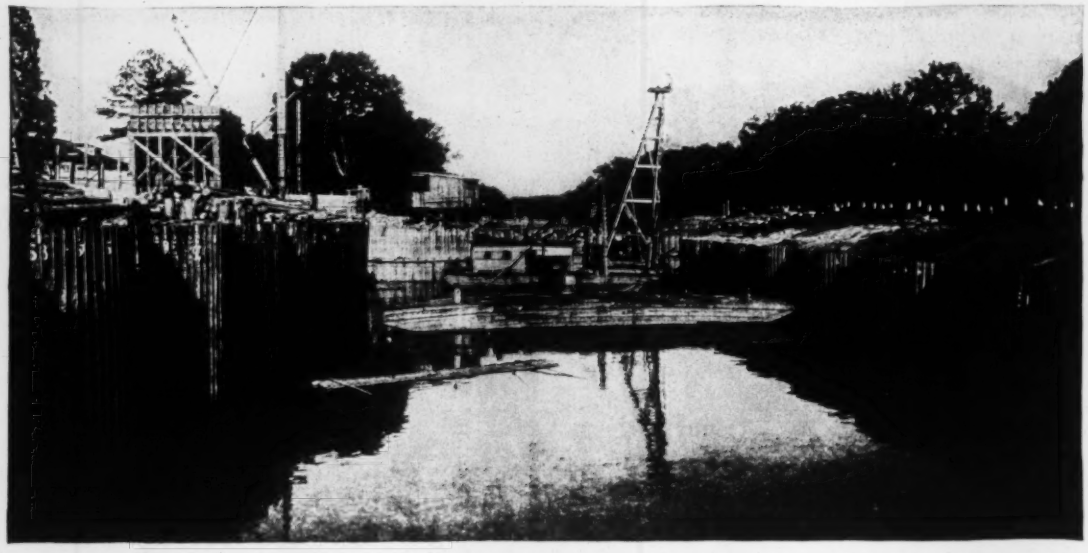
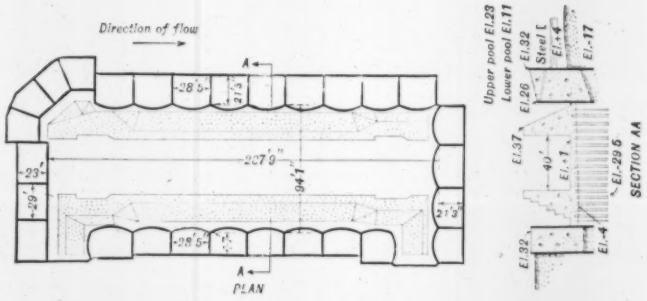


Designed under direction of Major H. W. Stickle, Corps of Engineers, U.S.A. by Capt. C. S. Ridley, District Engineer Officer, Norman Chivers, Assistant.

The Type Of Lackawanna Steel Sheet Piling Cofferdam Utilized In Constructing U. S. Government Lock No. 2, Cape Fear River, Brown's Landing, N. C.

This cofferdam consisted of double rows of Lackawanna Sheet Piling connected at intervals by transverse rows, forming pockets of such size that when filled with earth they could resist the unbalanced pressure on the cofferdam. The pockets on the river side were filled with material dredged from the enclosure, but on the land side, as the steel was driven well into the bank, in ground level with the tops of the pockets, no filling was necessary.



Pockets at the upper end had walls tied together by steel waling, cables and rods. The other pockets were without ties, the inside walls being curved to reduce distortion caused by filling. Two single wall panels held back by cables, were utilized in the upper and lower wings to meet space and driving requirements.

The Lackawanna Arched-Web section, on account of its greater transverse strength was used in walls held by waling and on the outside river pockets. The Straight-Web section was used in the interior curved walls, cross walls and on the outside of the land pockets.

Provision against flooding demanded for the top of the steel an elevation of 23.4 feet above mean low water which was about 28 feet above the average of the river bottom, or 31 feet above the lock floor.

Necessary penetration in the sand and clay river bottom demanded piles 49 feet long for the outside wall and the land side of the inside wall. On the river side of the inside wall, however, by using 43-foot sheet piles and making the wall 6 feet lower, and sloping the tops of the pockets, a saving was made in steel and filling required and dredging operations were facilitated.

All sheet piles in the inner wall were spliced just above the elevation of the lock floor, so that the lower portions could be left in place as a permanent protective cut-off wall—a practice which is now generally looked upon with the greatest favor.

Particulars as to the driving of sheet piling will be given next week, but if interested in this class of work, it will pay you to send *at once* for our book—"Lackawanna Steel Sheet Piling."

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Engineering News

VOLUME 76 DECEMBER 7, 1916 NUMBER 23

Activated-Sludge Results at Cleveland Reviewed--I

By R. Winthrop Pratt* and George B. Gascoigne†

SYNOPSIS—A comprehensive review of nearly a year's operation of one of the two largest activated-sludge plants in the United States.

Clarification

Cleveland's activated-sludge installation (*Engineering News*, Apr. 6, 1916) has now (Dec. 1) been in operation over nine months. Within 10 days after passing sewage through the plant, activated sludge was produced, but it took about two months to get all the recording apparatus tested out and the plant in shape for continuous operation. Of the remaining period about two months have been used for making alterations in the tanks, which are shown in Fig. 2. (A general view of the tanks is given in Fig. 1.) A number of tests have, however, been completed; and while the results obtained cannot be considered conclusive, they furnish some interesting data pertaining to this new process of sewage treatment.

For preliminary and comparative studies it was desired to substantiate as quickly as possible and under conditions comparable to those obtained in an actual plant, the data secured with the small experimental units (*Engineering News*, July 22, 1915). A schedule of operation embodying a number of short test runs was determined upon as the most feasible method for studying certain fundamental features of the process. When the results from a run show a consistent trend, the run is discontinued and a new one started. The conditions selected for the runs were such that difficulties that might develop during short-time runs or might give misleading results were reduced to a minimum.

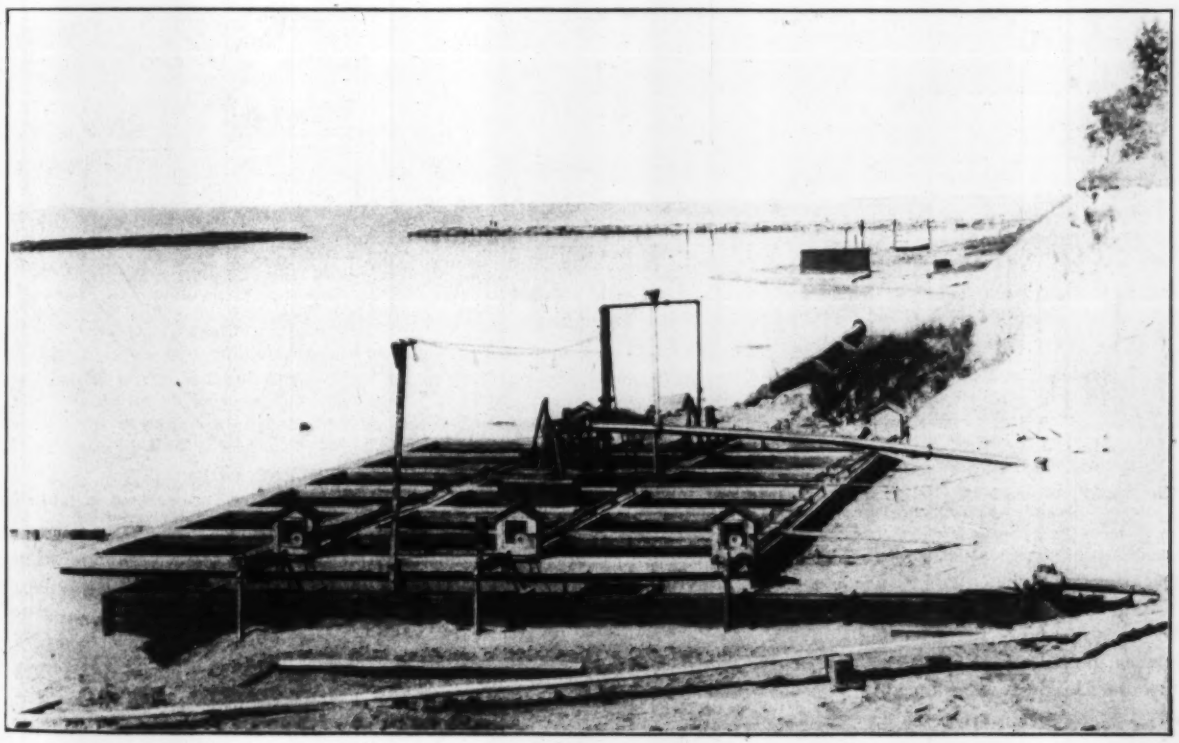

FIG. 1. GENERAL VIEW OF ACTIVATED-SLUDGE PLANT, CLEVELAND, OHIO

Degree of Purification Required

About 75% of Cleveland's sewage will be treated at two lake-front plants, making possible the use of the lake dilution opposite each. The conditions at these two plants, therefore, will require only a low degree of purifi-

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†Sanitary Engineer, Subdivision Sewage Disposal, City of Cleveland.

cation. At a third plant, for treating the remaining 25% of the city's sewage, there will be required a high degree of purification, as the effluent is discharged into the Cuyahoga River.

The first experiments at Cleveland with the activated-sludge process indicated that two important requirements of an ideal method of sewage treatment were being satisfied: The process produced a clear sparkling effluent, and there was an absence of odors. The process, therefore, appeals strongly to the average layman and sanitarian, which fact must be given due weight even though the cost may be high and certain phases of the process still remain undeveloped. To the writers' knowledge, the Cleveland installation was the first to be designed and operated under conditions where the degree of purification involves simply clarification. In other words, this type of plant was considered a competitor of a plant comprising sedimentation, supplemented with disinfection during the bathing season. As regards the results produced by the two types of plants the activated-sludge process not only clarifies the sewage as compared with partial clarification in sedimentation tanks, but eliminates the iron discoloration that occurs near the main sewer outlet and at times spreads over a considerable area. With sufficient data pertaining simply to clarification it will be possible to assume more readily the conditions for Cleveland's third or southerly plant, where the degree of purification must be carried to the point of stability or nitrification.

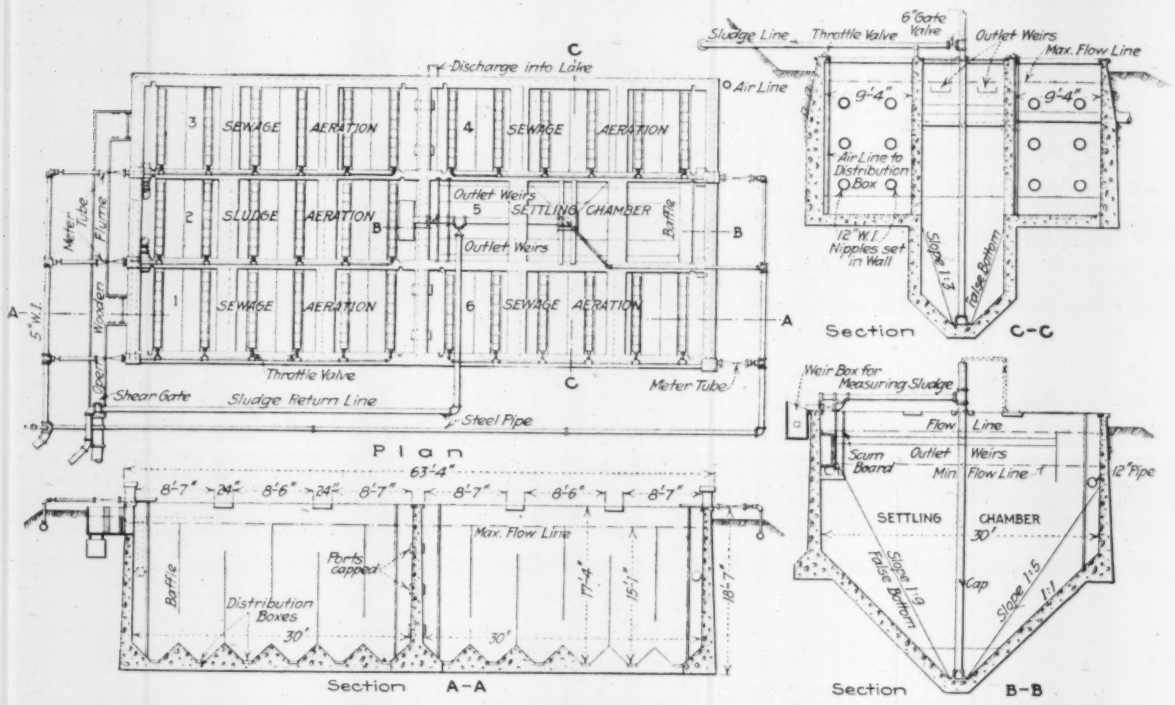


FIG. 2. PLAN AND SECTIONS OF ACTIVATED-SLUDGE TANKS, CLEVELAND, OHIO

The tanks as originally built were shown in "Engineering News," April 6, 1916. Baffles have since been added in tanks 3 and 4, weirs inserted in the settling chamber and the bottom slopes of the settling chamber made steeper

Theory of Activated-Sludge Process

The theory of the activated-sludge process involves properly conditioning a bacterial growth and bringing the growth into the most intimate contact with the suspended particles of the crude sewage. The plant, therefore, was divided into six compartments in order that the results obtained at the end of each step could be definitely studied and that, if necessary, the solid matter of the sewage could be aërated longer than the liquid itself.

A more recent development as regards the theory of the process, which is apparently local, owing to the large amount of iron salts in the crude sewage, involves the use of an active caustic, such as lime or its equivalent. Such a method of treatment would then resolve itself into a combination of chemical precipitation and the activated-sludge processes. A complete removal of the iron discoloration requires a longer aëration period by about three-quarters of an hour than is necessary for clarification alone. Apparently, this additional period is used for oxidizing the iron salts, and whether or not the action can be hurried by the addition of the lime is a question. Laboratory experiments in progress indicate that when lime is added to sludge it will settle more rapidly and that its digestion is retarded. Small amounts of lime probably will not reduce the value of the final sludge as a fertilizer ingredient.

The main intercepting sewer, which now discharges off shore near the activated-sludge plant, collects the sewage from the easterly district of the city by means of a combined system of sewers. The sewage for the plant is diverted from a shallow grit chamber about 2 ft. below the flow line and flows by gravity to the tanks. Practically all the grit has been removed from the sewage, but the sewage is distinctly stale, due principally to the average travel of 5 mi. The flow in the main sewer varies from 40,000,000 to 250,000,000 gal. per 24 hr., the normal dry-weather flow being 60,000,000 gal. The suspended solids average 250 parts per 1,000,000; organic nitrogen, 8.5 parts; free ammonia, 12.1 parts, while the iron content at times reaches 350 parts, averaging 21 parts. The excessive amounts of iron are due to pickling wastes, discharged when the domestic flow of sewage is low.

At first the sewage flows to the aërating tanks, where it is agitated with activated sludge supplied by the process. Compressed air forced through filtros plates in the bottom of the tanks produces the necessary agitation and commingling. After an agitation period sufficient to attach the suspended solids and the fine colloidal particles to the gelatinous surfaces of the activated sludge, the sewage passes to the settling compartment. There the sludge settles to the bottom of the chamber, due to a short retention period, the clear supernatant liquid passing off to the lake.

The settled and concentrated sludge in the bottom of the settling chamber is then lifted by compressed air into the sludge aëration or activation tank. Here the freshly made sludge is restored to its proper condition by aërating for a further period, after which it is ready to be mixed again with the crude sewage in the aërating tanks. In some of the tests the sludge was diverted back to the aërating tanks, bypassing the activation tank. Every day or so a certain amount of sludge is diverted from the settling compartment for experimental purposes or is wasted. Measurements are made regularly of the sludge depth in the settling compartment, and an increase or decrease of the same determines whether or not the amount withdrawn equals the amount of sludge produced. The line separating the liquid from the sludge can be definitely located.

Extraordinary precautions have been taken in operating the installation; and while at first they did not seem necessary, time has shown many of them to be well worth the trouble. Reference is made particularly to varying the quantity of sewage treated in accord with the flow in the interceptor; to the separation of the operation and analytical results according to the day- and night-sewage flows; and to the use of indicating meters on the air lines at the entrance of each compartment. The sampling schedule provides that the day- and night-sewage flow be separated into composite samples of 16 and 8 hourly portions respectively, and the analytical determinations are made from the composites. The above separation permits the use of smaller amounts of air during the low flows of dilute night sewage as compared to the greater quantity used with the larger flows of concentrated day sewage. Such a variation suggests controlling automatically the air used during the process and the possibility of loading during the daytime a municipal light plant, a condition that normally does not exist.

Air-Distribution System

Air is furnished by a hydro-turbine blower manufactured by the Nash Engineering Co., South Norwalk, Conn., and located in a frame building about 150 ft. from the tanks. The blower is motor-driven "belt drive" and delivers air to a separator and then to a pulsation- and moisture-reducing steel tank 3 ft. in diameter and 6 ft. long. This particular type of compressor makes little noise and eliminates treating the air to remove dust and oil, which might clog the filtros plates in the aërating tanks. The compressor did not deliver a moisture-free air last winter, but when freezing conditions again prevail, an additional separator will be used at the tanks. The air as it leaves the compressor is measured by a General Electric air-flow meter and before its delivery to the tanks is again registered by indicating meters located at the entrance to each compartment. Thermometers and pressure gages are installed in the compressor house and at the tanks, and readings are taken hourly. The compressor operates at a pressure of 9 lb. per sq.in. with 14.5 ft. of sewage above the filtros plates and compresses about 450 cu.ft. of free air per minute. The efficiency of the installation, all told, is about 33%.

The medium used for diffusing the air consists of filtros plates (R-5) set in structural-steel boxes placed in the valleys of the ridged bottom. The plates were furnished by the General Filtration Co., Rochester, N. Y., and were delivered to the work before this company had its own manufacturing plant. The plates are 12 in. square and 1½ in. thick. Eight are set together with sulphur joints in a steel box. The boxes are placed across the tanks and at right angles to the direction of the flow. The ratio of plate surface to the superficial area of the tank is 1 to 5.

OPERATION AND ANALYTICAL RESULTS FOR TWELVE RUNS, CLEVELAND ACTIVATED-SLUDGE PLANT

OPERATION RESULTS—NIGHT AND DAY SEWAGE

No. of Run	Temperature, Degrees C. Atmos.	Comp. Air	Inf.	Eff.	Period of Operation	Quantity Treated, M. Gal. per 24 Hr.	Aëration Period, Hr. Liquid	Aëration Period, Hr. Solids	Settling Period, Min.	Sludge Returned Moisture Content, %	Sludge Returned % of Sewage Treated	Free Air Used in Cubic Feet per Gal. Sq.Ft. per Sewage	Free Air Used in Cubic Feet per Gal. Min. Sludge	Free Air Used in Cubic Feet per Gal. Sewage Treated
1	6.3	13.0	13.7	14.0	4/1 to 4/22	472	2.2	3.3	42	97.90	34.0	0.26	0.28	1.30
2	12.0	12.7	17.0	17.0	5/8 to 5/19	408	2.7	4.3	47	97.85	25.4	0.25	0.27	1.29
3	17.0	17.3	18.0	18.0	5/24 to 5/31	429	1.3	2.9	45	97.89	25.0	0.43	0.27	1.09
4	16.7	15.3	19.0	19.0	6/1 to 6/8	458	1.2	2.7	42	97.37	24.8	0.35	0.27	0.92
5	16.7	15.3	19.0	19.0	6/10 to 6/20	481	1.1	1.1	40	97.84	24.9	0.35	....	0.58
6	18.3	17.7	20.0	20.0	6/21 to 6/27	460	1.2	1.2	41	98.00	25.8	0.25	....	0.47
7	22.0	29.6	25.7	25.7	8/10 to 8/15	419	2.0	2.0	45	98.13	25.2	0.40	....	0.76
8	26.0	30.4	26.7	27.0	8/18 to 8/21	339	2.5	2.5	66	99.10	25.9	0.25	....	0.61
9	20.6	27.6	27.0	27.0	8/24 to 8/25	435	1.9	3.5	43	98.35	25.4	0.25	0.25	0.47
10	20.2	27.0	26.0	26.0	8/25 to 9/3	398	2.1	3.8	48	98.08	26.2	0.31	0.40	0.62
11	24.4	28.7	25.7	25.7	9/4 to 9/8	383	2.3	4.0	55	99.21	26.6	0.30	0.40	0.68
12	14.3	21.3	24.0	23.6	9/18 to 9/24	282	3.0	3.0	67	98.32	25.0	0.26	....	0.74

Retention periods in activation tank based on 25% displacement, runs 1 to 12 inclusive.
Retention periods in aerating tank based on 40% displacement, runs 1 to 6 inclusive.
Retention periods in aerating tank based on 75% displacement, runs 7 to 12 inclusive.

ANALYTICAL DATA, NIGHT AND DAY SEWAGE

No. of Run	Oxygen Consumed—Dissolved Inf.	Oxygen Consumed—Dissolved Eff.	Oxygen Consumed—Total Inf.	Oxygen Consumed—Total Eff.	Nitrogen—Organic Inf.	Nitrogen—Organic Eff.	Nitrogen—Free Ammonia Inf.	Nitrogen—Free Ammonia Eff.	Iron (Total) Inf.	Iron (Total) Eff.	Suspended Matter Inf.	Suspended Matter Eff.	Turbidity
1	32.1	14.1	63.5	17.5	9.1	4.4	11.7	11.1	.....	.....	250	38	..
2	30.5	12.7	62.1	27.8	8.0	1.4	12.4	9.3	.....	.....	262	15	..
3	30.0	12.3	64.5	14.1	....	....	11.7	8.8	.....	.....	284	..	..
4	27.4		61.4	13.5	....	....	13.3	10.2	.....	.....	229	..	23
5	29.6	14.6	62.3	13.9	....	....	13.6	11.0	.....	.....	274	..	26
6	33.4	16.6	64.6	13.4	....	....	14.5	12.3	.....	.....	252	23	..
7	27.1	13.1	55.7	15.8	....	....	8.6	6.9	11.7	2.4	210	16	23
8	25.6	12.4	51.7	9.4	....	....	8.7	5.9	20.8	2.4	219	27	40
9	21.1	11.5	50.0	11.4	....	....	11.0	7.5	20.5	2.0	185	19	31
10	22.8	12.7	57.2	13.7	13.3	6.8	9.2	7.2	14.2	2.0	255	38	38
11	25.8	14.4	62.4	19.2	15.4	9.5	10.7	9.8	15.0	6.2	309	65	98
12	26.5	14.6	60.0	14.8	12.5	5.6	9.6	6.0	21.5	1.1	234	33	35

REMARKS ON EACH RUN—1, 2, 3 and 4. Good effluent. 5 and 6. Colored effluent. 7. Good effluent. Sludge not satisfactory. 8. Good effluent. Sludge darker than normal with slight odor. 9. Ebullition starts in settling tank. Poor sludge. 10. Ebullition in settling tank. Poor sludge. 11. Ebullition in settling tank very active. Sludge had bad odor. 12. Guides for controlling ebullition in place. Sludge satisfactory. Motor trouble 9/25.

No means was provided for cleaning the plates while in place, but it was intended to remove a box of plates without putting the compartment out of operation. This has proved to be impracticable, because in a 14-ft. depth of sewage it is almost impossible to locate with a lifting hook the small hole in the lug attached to the end of the steel boxes. As a consequence, the tanks are shut down when it is desired to change or inspect the plates. The position of the plates can be noted during operation by the greater amount of ebullition at the surface, but the writers consider that the distribution has been fairly satisfactory.

The filtros plates have been in continuous use for eight months. The surface of the plates clogs with either fine particles of sludge or a bacterial growth, and about a $\frac{1}{4}$ lb. more pressure is required to force the air through the plates after this period of operation. When the plates are wet through, they crumble easily, while some flake off; but upon drying they again harden. The surface of the plate next to the compressed air remains clean and porous.

At the present time (Dec. 1) 4-in. perforated pipes are placed in the bottom of aërating tank No. 1. The holes are $\frac{3}{64}$ in. in diameter, 4 in. apart, staggered and located on the under side of the pipe at the 45-degree point. It is intended to lift the pipes out of the tanks for cleaning, as no steam or water connections are provided. It will not be necessary, when removing the perforated pipes, to shut off the flow to a tank.

Discussion of Results—General

The schedule of operation as regards clarification provides, first, for a number of runs when the aëration period for both the liquid and the solids is equal, and, second, when the activation tank is used or when the aëration periods differ. A survey of the runs already completed indicates that the first four were used in establishing the maximum capacity of the settling tank. Runs 5 and 6 were then started and conform to the regular schedule. Due to an accumulation of bad sludge on the bottom of the settling tank it was necessary to stop run 6 and remove the sludge. At this time the effectiveness of the aëration tanks was increased by installing vertical baffles and the false bottom placed in the settling tank. By Aug. 10, after a reconstruction period of six weeks, the plant was again ready to operate. Since Aug. 25 the plant has been out of operation three weeks, due to motor trouble. The plant was designed to treat 1½% of the normal dry-weather flow in the intercepting sewer, which is equivalent to 900,000 gal. per 24 hr. An allowance was made for a fluctuation in the flow of 25% and a return of activated sludge equaling 25% of the sewage treated. With such a high flow it was impossible to secure an effluent free from fine sludge particles. Consequently, the capacity of the installation has always been controlled by the quantity of sewage that the settling compartment can satisfactorily treat. A flow varying from 280,000 to 480,000 gal. per 24 hr., with a 25% fluctuation, has been treated at times by one-half and at other times by two-thirds of the entire installation. The results indicate that about 2,500 sq.ft. of superficial tank area with a sewage-aëration depth of 15 ft. is sufficient to treat 1,000,000 gal. of sewage. This figure applies for conditions occurring during run 12 and contemplates the production of a clarified effluent.

The Cleveland sewage-testing station is located on the lake front and is consequently exposed to the most severe weather conditions. Sewage was for the first time passed through the plant on Feb. 10, 1916, when the temperature was 22° F. and the bottom of the tanks was covered with ice. Within 10 days activated sludge was produced—during a time when the temperature of the atmosphere varied from 14 to 43° F. and that of the treated sewage from 54 to 59°. The sludge was typical in appearance and settled as rapidly as any produced since then. There appears no reason why an activated-sludge plant cannot be placed in operation during the coldest months of the year. As regards the effect of temperature on efficient operation the results of the coming winter are looked forward to. During that time a final schedule of operation comparable to that obtaining under actual plant conditions will be in force.

The installation as designed and constructed provides for four sewage-aërating tanks, each rectangular in shape and with the flow horizontal. The displacement volume was assumed at 100%, due to the agitation, but salt tests have shown that the effective displacement was only 40%. In order to prevent short-circuiting through the tanks and to increase the effective displacement, vertical baffles were installed during July in compartments 3 and 4. The tanks then became vertical-flow instead of horizontal-flow tanks, and according to the salt tests 75% of their volume was made effective. It might be possible to again increase slightly the volume displacement of the tanks by decreasing the depth of the opening beneath the baffles. The baffles at present are 3 ft. above the ridges. They have been installed (Dec. 1) in the activation tank with the flow areas above and below them restricted to 18 in.

The original experiments indicated that an aëration period of half an hour was sufficient to produce clarification, but such a short period is not enough to condition the sludge properly, and has not as yet been attempted with the present installation. This is due to the facts that the activation or sludge-aërating tank was not considered efficient without vertical baffles and that it was desired to determine first what results could be obtained without using this tank. Run 12, with an aëration period for both liquid and solids of 3 hr., had only been in progress a little over a week when motor trouble put the plant out of operation. The results secured during this run are, however, considered representative when operating a plant without the use of the activation tank. The schedule of operation provides for a longer run during winter conditions and after data as conclusive are secured with the activation tank in use.

Sedimentation Results

The settling tank is rectangular, of the horizontal-flow type and made so as to fit in with the other tanks of the unit. Its bottom was hoppered with the end bottoms at a slope of 1 to 1. In order to provide these slopes and in addition get sufficient capacity the tank is 30 ft. deep at its lowest point. Under such conditions it has been possible to secure a sludge continuously with a 98% moisture content, but impossible with such slopes to collect all the sludge at the discharge pipe. An accumulation was found to collect on the bottoms and sooner or later, depending upon the time of the year, to interfere with the operation of the tank. Before the installation of the false bottoms during July it was frequently necessary to pump down the tank and remove the bad sludge. The new slopes prevent any deposit on their sides, but ebullition from the sludge behind the false bottoms produced the abnormal results shown in run 11. This ebullition has been cor-

veyed to gas vents by guides along the walls of the tank and the trouble eliminated. Since the installation of the steeper slopes the moisture content of the sludge has been increased about ¾%, a result which is in accord with its reduced retention period. The settling compartment has never been operated with a blanket of sludge to act as a sieve for removing fine suspended particles from the effluent. The best results as regards a clear and sparkling effluent have been obtained when the sludge line was from 16 to 19 ft. below the flow line in the tank.

As mentioned before, the capacity of the settling tank has controlled the quantity of sewage treated by the installation. The three most important factors regarding the design and operation of the settling tank are the retention period, flowing-through velocity and the necessity of having the sludge in a settleable condition. With flows varying from 300,000 to 675,000 gal. per 24 hr., the effective depth of the tank both with the new and the old slopes remains about constant, or 8 ft. With a flow of 675,000 gal. per 24 hr., which is the maximum rate at which there is an absence of fine sludge particles in the effluent, the actual velocity is 1 ft. per min. and the retention period 35 min. Whether or not a shorter period of retention will suffice is an open question pertaining to an efficient settling tank of the horizontal-flow type. Two long effluent channels have been placed in the tanks, as shown. They will permit an examination of the liquor at various periods of settling, the liquor flowing into the channel near the baffle at the inlet having a very short period, while the longest period occurs for the liquor entering the troughs at the opposite end.

Proportion of Sludge Returned

The proportion of sludge returned to the aërating tanks has remained practically the same in all the runs—about 25% of the sewage treated. The proportion can no doubt be reduced; but the solution of this phase of the matter is left to the final schedule of operation, when it will be the only condition varying. The moisture content of the sludge returned was determined from one sample taken during the daytime. The quantity is measured by a weir, no allowance being made for a slight variation in the moisture content. In order to check the operator's work in regulating the flow over the weir a composite sample is taken from the aërating tanks and the solid matter determined by the evaporation method. There is a maximum variation in the solid matter returned to the sewage of about 30%.

Naturally, a great deal of thought has been given to the quantity of air necessary to produce certain results. The original experiments indicate that the use of 0.2 cu.ft. of air per square foot of aërating surface was the minimum permissible, while the improvement due to the use of 0.3 cu.ft. instead of 0.25 did not appear justified. The results obtained with the large installation have, in the main, verified those obtained with the experimental units. Special mention is made of runs 7, 8 and 12, in which the aëration period has varied from 2 to 3 hr., the quantity of sewage treated varying from 282,000 to 419,000 gal. per 24 hr., while the quantity of air used per gallon of sewage treated is practically constant.

In comparing the work accomplished by aërating tanks of different depths it is evident that the unit "cubic feet of air used per gallon of sewage treated" is not a true index of either the power units required or the purification obtained. It is generally recognized that the amount of air required to produce certain results is inversely proportional to the aërating depth. An absolute unit that is proportional to the power units used, irrespective of the aërating depth and to the degree of purification expected, is badly needed. The product of the cubic feet of air used per gallon of sewage and the aërating depth gives such a unit. A. G. Husted has suggested the name "foot-feet" for this unit. To illustrate: An installation using 1½ cu.ft. of air per gallon of sewage with an aërating depth of 10 ft. will use 15 foot-feet per gallon of sewage flow. An installation using ¾ cu.ft. of air with an aërating depth of 20 ft. will also use 15 foot-feet.

Cost of Activated-Sludge Process

A cost consideration of the activated-sludge process resolves itself, primarily, into a study of the life of such a plant, the initial expenditure necessary for its construction and the fixed and operation, or maintenance, charges. The following data pertain only to the operation, or maintenance, charges, but recent estimates indicate that the annual fixed charges about equal the operation charges, exclusive of the sludge-disposal and land factors of the problem.

The first published data concerning the activated-sludge process mentioned the possible high cost of operating a plant of this type. Sufficient data have been secured with the present installation for estimating fairly accurately just what this cost will be when the degree of purification involves only clarification, and the liquid and solids are aërated equally. Operation charges may for convenience be divided into the following items: Supervision, labor, power, repairs and supplies and incidentals, with the unit cost of power and labor usually governing. Cleveland conditions as regards the cost of electricity are favorable to this method of treatment, a figure of ¾c. per kw.-hr. being considered conservative. With the following assumptions, which are considered the best to expect with present data, a minimum cost of operation for power alone is $3.75 per 1,000,000 gal. of sewage treated:

Normal flow of sewage per 24 hr	25,000,000 gal.
Depth of sewage above air diffusers	15 ft.
Working pressure per square inch	8 lb.
Air-installation efficiency	50%
Average aeration period of liquid and solids	3 hr.
Quantity of air per gallon of sewage	1 cu.ft.

In operating sewage-treatment works it is of import that the grade of operators and workmen required for different types of plants varies. An activated-sludge operator must be intelligent, able to write, and trustworthy in the extreme. Common laborers are not satisfactory for performing the duties of an operator around an activated-sludge plant. It may also be said that the degree of supervision should vary with different types of plants. It is therefore evident to the writers that the advantage in simplicity of management does not lie with the plant involving the activated-sludge process of sewage treatment. In estimating recently the labor item for a 25,000,000-gal. plant a figure of 75c. per 1,000,000 gal. of sewage treated was used, the same involving 50 man-hours every day of operation.

Summarizing, the minimum cost of operation per 1,000,000 gal. of sewage treated is $4.50 for the labor and power items. The uncertainty attached to the cost of repairs, supplies and incidentals makes it impossible to give an accurate estimate of what they will be. A conservative estimate of their cost, including supervision, is 50c. Consequently, the minimum operation cost to be

expected is estimated at $5 per 1,000,000 gal. of sewage treated, exclusive of sludge disposal.

A number of points in connection with the process have developed as the work progressed. The most important of these involve the use of fine screens prior to activation, the possibility of a revenue from the grease skimmed from the settling tank, an efficient depth of aërating tank and the necessity for bacterial determinations when only clarification is involved. Preparations at this time are being made to secure the data pertaining to the latter point.

As regards the use of fine screens (mesh less than ½ in.) prior to activation it is believed that the results produced do not warrant the cost of operation. Two sets of bar screens with 1½-in. openings and in series are sufficient to remove the coarser particles that decrease the manurial value of the sludge and yet pass all particles that may aid in rapidly settling the sludge.

At the inlet to the settling tank a baffle that extends down into the tank about 7½ ft. provides a means for concentrating the scum liberated by the air agitation. Every week the scum has been removed, weighed and the grease determined. About 65% of the scum is grease, the same averaging 20 lb. per 1,000,000 gal. of sewage treated. As time permits, it is intended to make the data pertaining to this phase of the problem more conclusive.

The efficient depth for aërating tanks depends upon the area available and the foundation encountered. In order to prevent placing the tanks on piling, it would appear advisable to deepen them. A recent design by the writers for an activated-sludge plant provided that the depth of sewage above the air diffusers be 25 ft. The additional head against which the air must be forced is compensated for by the greater amount of work accomplished.

Summary and Conclusions

The activated-sludge process of sewage treatment produces a clear, sparkling effluent with an absence of odors.

There appears to be no reason why an activated-sludge installation cannot be placed in operation during the coldest months of the year.

The use of a hydro-turbine blower, whereby the air is washed, prevents the clogging of air diffusers with oil or fine particles of dust or other impurities.

The activated-sludge process does not have the advantage of being simply to operate.

When the treatment involves simply clarification and when the liquid and solids are aërated equally the minimum period required is 3 hr., and

Three-fourths of a cubic foot of free air per gallon of sewage treated with an aërating depth of 15 ft. is required. Apparently, such a long period of aëration is only necessary to condition the sludge properly.

An acre of land provides sufficient aërating and settling space to treat daily approximately 15,000,000 gal. of sewage with an aërating depth of 15 ft.

With a large installation the minimum operation cost of sewage treated is $5, exclusive of the sludge-disposal cost. This figure is based on the use of electricity for power purposes at ¾c. per kw.-hr. The fixed charges would be an addition to the figure stated.

If the sludge is re-aërated separately, the period necessary to aërate the mixture of activated sludge and fresh sewage is less than 3 hr.

The maximum velocity permissible in a settling tank of the horizontal flow type is 1 ft. per min. The question of the proper retention period required remains undecided. The results indicate that 30 min. is ample, if not more than necessary.

Storing and Measuring Oil from a California Gusher

By George D. Roalfe*

An unexpected and an unprovided for gusher on the property of the Lake View No. 2 Oil Co., in the Sunset-Midway oil fields 25 mi. southwest of Bakersfield, Calif., flowed at about the average rate of 20,000 bbl. per day for over 150 days, producing 3,000,000 bbl. of oil emulsion. Storage had to be provided quickly for this immense flow, as well as for oil that has subsequently been produced, at intervals, at the rate of 30,000 bbl. per day.

When the well came in the first time, its force was so great that it carried the string of tools, weighing several thousand pounds, through the top of the derrick. The oil in addition to flowing under great pressure became mixed with at least one stream of groundwater. The result was about as perfect a mechanical mixture as one could conceive of. This mixture or emulsion, as it is called, contained about 65% by volume of water and base sediments.

Use of Old Reservoirs

The conditions were such as to make the problem of storage a vital one. This oil field had had a similar well, for which the owners had constructed earth-banked reservoirs having a capacity of 1,500,000 bbl. But these reservoirs or sumps were about 3 mi. from the new gusher and in addition were slightly higher. To utilize them a ditch was dug from the well, for a distance of about 1½ mi., to some sumps of several hundred thousand barrels capacity. A pumping station was placed here, and an 8-in. pipe line was run to a treating plant and then on to a large sump with a branch line to a smaller one. A 6-in. line was also run to a larger sump higher in the hills, which, however, it was not found necessary to use.

All these sumps could be used with slight repairs. An additional sump was formed by building 950 ft. of embankment from 1 to 25 ft. high. Five of the sumps were so located that they came in at least two pieces of property, complicating the determination of rental. To determine the amount of stored oil in the settlement of the rentals, Daniel S. Halladay, consulting engineer, Los Angeles, Calif., was retained. The writer was in charge of the fieldwork for Mr. Halladay.

Cross-Sectioning Reservoirs

An interval of 25 ft. was decided upon as the proper distance between cross-sections. In the case of each separate sump a base was laid out in a direction generally parallel to the longer axis of the reservoir. The reservoir was then inclosed in a rectangle. Stakes were set every 25 ft. on both the base line and on the line parallel to it on the opposite side of the sump, forming a system of rectilinear coördinates.

In some cases it was considered advisable to place stakes on the bank opposite the base line at locations other than those on the side of the rectangle as described; in this event the stakes were placed at the nearest points outside of the sump area whose values of x and y were some even multiple of 25 ft.

All elevations, whether taken with a rod and level or with the sounding tape, were referred to a plane passing through a point at some even foot of elevation. To this

*Los Angeles, Calif.

elevation the fixed point on the permanent gage rods was afterward set as described farther on. The distance of any point below this plane was the value of the ordinate z.

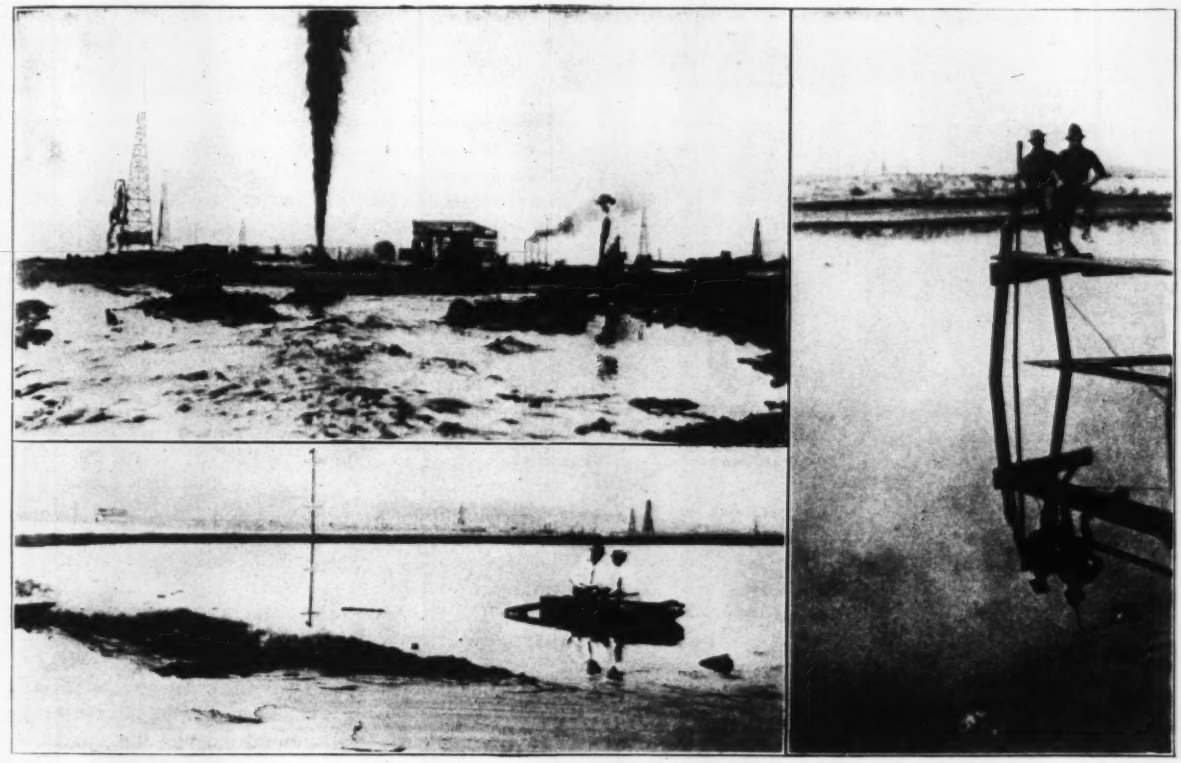
To get measurements across the sump a cable was constructed of No. 12 steel wire in 25-ft. links. Each joint was tagged; and as it often fell into the heavy black oil, instead of stamped numbers a system of notches was used for graduation. One notch on the side represented 25 ft.; two, 50 ft., and so on, while each notch on the bottom represented 100 ft. When 500 was reached, instead of making five notches a hole was punched in the middle of the tag. Then 600 became a hole in the center and a notch at the bottom; 6 + 25 was a hole in the center and one notch each on the bottom and the side, etc.

When the sump was over 300 ft. wide, it was found necessary to place floats about every 75 ft. to keep the wire from dropping under the surface of the oil. This

up of sections of ¼-in. pipe about 3 ft. long. On the bottom of the lowest section was a hook so placed that when the ring in the sounding tape, to which the bob was attached, was placed over it, the zero on the tape would coincide with the bottom of the rod.

The sections of the pipe were each fitted on one end with a coupling; and as the soundings were taken in greater depths, additional sections were added. To hold the tape in place against the rod and at the same time make the removal of a section simple, rings were used that were very similar to the ordinary key ring, enabling the tape to be slipped in or out.

The boat used in taking the soundings was made of galvanized iron. It was flat-bottomed, square-ended and reinforced around the top with a piece of ¾-in. channel put on with ¼-in. rivets. A piece of 2x4-in. timber was fastened along the gunwales; two large spikes driven into



MEASURING OIL STORED IN EARTH-BANKED RESERVOIRS, CALIFORNIA

was not so important in the summer as in winter, nor so essential in sounding as in moving the cable. During the summer months the oil was quite liquid, especially during the working day; but in winter, when some rain occurred, the oil had the consistency of firm butter and it was necessary to use a horse in drawing the gaging boat across the sump.

Sounding in Thick Oil

For sounding, when the oil was liquid, a steel tape and 6-oz. lead bob were used. At first, as the weather grew colder, the oil hardened on the surface only; and when the sun had shone for a short while, this crust was softened so that the tape could be used. But when this layer became thick, only the top was melted and a rod had to be used for the sounding. This rod was made

this acted as oar locks. When drawing the boat with a horse, a sling of cable was carried completely around near the top and fastened about a foot in front.

The floats for buoying up the cable were made of two pieces of 2x4, about 2 ft. long, nailed at their centers to the ends of a 2-ft. piece of 1x12. (Smaller ones were tried, but were not stable.) In the center a large spike was driven and the cable fastened to this with a piece of wire.

Before the oil was sounded, an elevation was taken on its surface. This was done by driving a stake flush with the surface of the oil and then taking a rod reading on this stake. (Benchmarks, of course, had been previously established.) Next, a gage rod was set with which it was possible to determine the variation in the surface of the oil. This was necessary because in nearly every instance the

measurements were taken while the sump was being filled, emptied or both. Owing to the solvent action of the oil on the paint of an ordinary level rod, temporary rods were made of a piece of 1x3-in. planed lumber notched with tenths completely across, and half-tenths halfway across one of the 3-in. surfaces.

The cable with 25-ft. graduations was next set between the two stakes, and readings were taken with a rod or sounding tape, depending on whether the point fell on the bank or in the body of the sump. In only one case did negative values of y appear. The layout was intended to eliminate them. If the contour of the ground necessitated it, shots were taken at other points than those on the 25-ft. intersection lines, as $y = 0 + 5$; $x = 1 + 51$, etc.

The cable was moved to the next pair of stakes and the operation repeated on the return trip. A sample of the method of keeping notes both for level and rod and for soundings is shown.

SAMPLE OF SURVEY NOTES—OIL-STORAGE DETERMINATION

George D. Roalfe, J. W. Howard, G. H. Robertson } Chainmen — SUMP NO. 10

Sec. 34, T. 32S, R. 24E, M. D. B. and M.

Sta.	+R	H.I.	—R	Ele.
B. M. No. 1	3.82	610.82		607.00
T.P.	.....	.....	4.08	606.79

X	Y	Z	+R	H.I.	—R	El.
0+57.30	0+38.10	1.93	.....	610.82	4.75	606.07
0+75.00	0+28.50	1.53	.....	.....	4.35	606.47
1+00.00	0+22.10	1.63	.....	.....	4.45	606.37

X	Y	Z	O.S.	Sounding	El.
1+02.2	0+25.0	3.21	604.79	0	604.79
1+25.0	0+22.3	3.21	.....	0	604.79
1+12.5	0+25.0	4.46	.....	1.25	603.54
1+25.0	0+25.0	5.92	.....	2.71	602.08

COMPUTING QUANTITY TABLES

The notes on each sump were plotted on a scale of 20 ft. = 1 in., and the 1-ft. contours were sketched in. The area included by each contour was determined with a planimeter. The volume between contours was computed in barrels and for every ¼ in. of elevation.

In order to use the tables it was necessary to have a fixed datum to refer elevations to, for the scheme was the reverse of that applicable to steel tanks (where the distance between a plate on the bottom of the tank and the surface of the contents is measured). Any sediment that might be deposited would soon render measurements based on that method more or less inaccurate.

Instead, a datum above the oil was used. A 2-in. iron pipe with an iron clamp attached to the top was driven firmly into the bed of the sump. The point of this clamp was set to a proper elevation. Thus the zero point would be always accessible and any movement would soon be detected and remedied. The pipe was driven at the end of a small pier (see accompanying illustration).

A study to determine the accuracy of the tables resulted in a check of within 1% on three successive days. Three sumps were used containing, when full, 111,119 and 113,249 and 542,548 bbl. respectively. The oil was moved from one to the other. Taking the volumes that corresponded to the elevations from the tables gave results that agreed within 1%. The method of measurement was such that the probable error was small in the upper portions of the sump at least. In the lower portions it was greater; but as the volumes were relatively small, its effect would not be great on the total figures. It is believed that the figures were generally within 3% of the truth.

The cost of the survey and office work is estimated as follows:

Sump No.	Contents, Bbl.	Cost of Field Work per Bbl., Cents	Cost of Office Work per Bbl. Cents
19	514,920	0.114	0.006
4, 5, 6, 9, 10, 11 and South Midway	2,010,324	0.085	0.030

In the case of sump No. 19 a different method was used. Control lines were run up the bottom of the gullies and around the perimeter of the sump. From the points on these lines random shots were taken, using the rod and tape and the rod alone, at points where slope of the ground changed. The office work followed the method given above. In the costs given the office work for sump No. 19 does not include a table, only the quantities for even feet of elevation being computed.

The gaging piers and rods were made of used stuff, but if made of new material would have cost on an average about $50. In these costs the chainmen were figured at $3.50 per day, the prevailing rate for labor in the field. All the help had to be broken in, as none had had any experience.

In the case of the sumps that were on several pieces of property, tables were computed for the several portions as well as for the total contents. To get the portion in a given property the dividing lines were platted and measured with the planimeter, as already described. These costs are included above.

Machine Trenching for Long Telephone Conduits

The adaptability of trenching machines for excavating the comparatively narrow and shallow trenches for telephone and telegraph conduits has been proved in several cases, although contractors for such work are generally inclined to employ hand labor. With the present scarcity of labor, however, the use of machinery offers special advantages. During 1916, highly successful results were obtained in about 35,000 ft. of trenching for the Wisconsin Telephone Co., of Milwaukee, Wis. This work was done by the company's forces, under the direction of C. W. Wilson, Superintendent of Exchange Construction.

The work was mainly in macadamized streets and to some extent along country roads. In streets having a concrete base the work was done by hand, as the machine would be too slow and it would damage the surrounding pavement. The materials were mainly earth, gravel and tough clay, with some sand and soft loam. Boulders and niggerheads that were encountered were generally disposed of by burying in holes dug in the sides of the trench, but in some cases they were broken up by blasting.

An objection commonly made to the use of a trenching machine on such work is that it cannot be operated continuously, as long stretches of open trench are undesirable and the conduit laying and backfilling must follow as soon as possible. The usual practice is to cut the trench between two manholes (average distance, 500 ft.) and then stop the machine until the tile laying and backfilling gang has this stretch of work completed and the paving relaid. Thus the machine is idle about 66% of the working time, but the results have shown that its use would be economical even if it were idle 75% of the time. This is for a machine with internal-combustion engine and would not apply with a steam-operated machine.

The machine used is of the wheel type, built by the Pawling & Harnischfeger Co., Milwaukee, for this kind of work. It is similar to the company's drainage excavator, described in *Engineering News*, Sept. 2, 1915. It has a cutting wheel 7½ ft. in diameter, digging a trench 15, 18 or 21 in. wide and with a maximum depth of 5½ ft. The width is usually 15 in., but for depths of over 4 ft. the cutters are shifted so as to make an 18- or 21-in. trench, as the men cannot work conveniently in the narrower deep trench. Where the depth exceeds 5½ ft., the additional cut is made by hand, for while machines are made that will cut deeper, the amount of such work is so small as to make it unnecessary to incur the extra expense for such a machine.

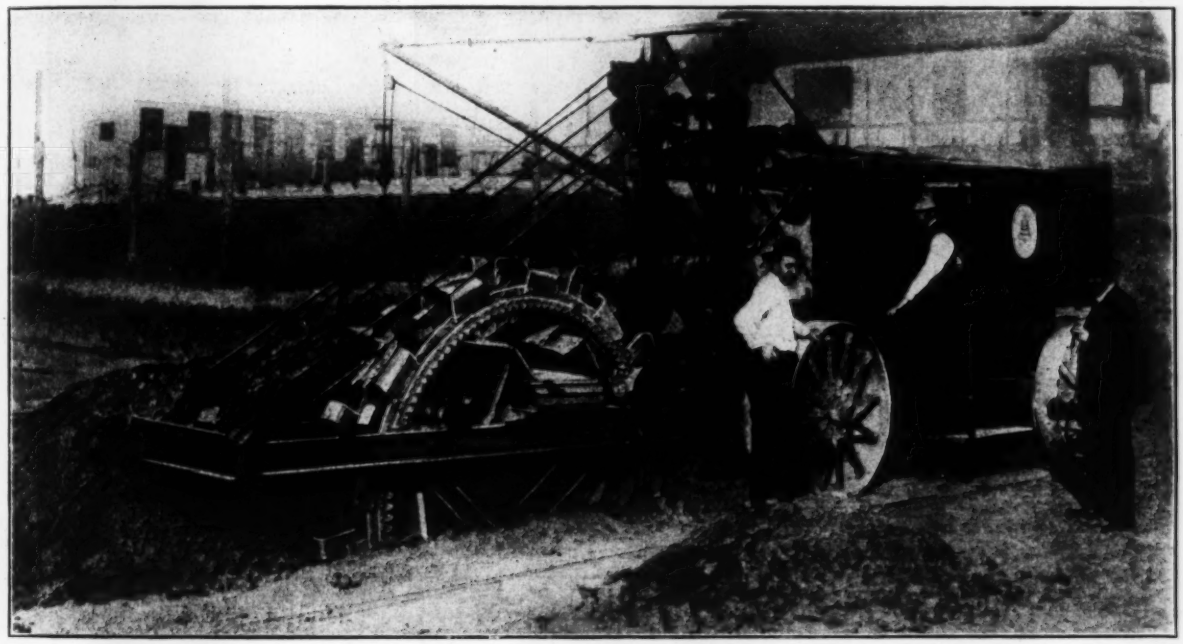
The trenching machine is mounted on four wheels and weighs about 9 tons. It is driven by a 25-hp. 4-cylinder kerosene engine, which uses gasoline for starting. It has six speeds from 2½ to 7½ ft. per min., but is operated mainly on the gear for 3½ ft. per min. This is equivalent to 210 ft. per hr. There are two men—an operator and helper. When the machine has finished its stretch of work, these men are assigned to other duty with the gang; but this would not be practicable with the men in charge of a steam-operated machine. Repairs have been insignificant, and after six months' work the cutters on the buckets were still in serviceable condition.

With the machine and gang of 20 men, about 600 ft. of conduit can be laid per day. This includes trenching, tile-laying, concreting, backfilling and paving. With handwork, a gang of 60 men would do about 600 ft. per day.

It was thought at first that there might be trouble from tearing up the gas-service pipes. But their location is shown by the shut-off boxes inside the curb, and their depth is determined by sounding. It is then easy to raise the excavator wheel to clear the pipes. On the 35,000 ft. of trench only half a dozen service pipes were damaged by the excavator. In each case the gas company was notified, and the telephone company paid the cost of repairs.

The backfilling is thrown in by a gang of six to eight shovelers and is machine tamped. This tamper has a vertical ram that is raised and dropped by power, and a 3-hp. gasoline engine operates the ram and the propelling gear. Its travel is about 8 ft. per min. The material is tamped dry, and there have been no complaints on account of settlement of the trench. With handwork there are three shovelers to one tamper, and 24 men are required in order to do the same amount of work as the nine men with the machine (including operator). Besides this, the work is not so well done.

The total number of men in the conduit gang is about 30 (including those building the manholes), and most of them do different parts of the work, as required from time to time. With the trench completed between the manholes, the concrete base is first laid. For this work there are two men in the trench for each tile-laying crew. Then two tile-laying crews are started at the middle (the summit) and work toward each end. Each crew has four men—two laying tile, one helper above to handle tile and one cementing the joints. Then the earth filling is packed against the sides of the conduit, the concrete cover is placed, and the backfilling is done.



TRENCHING MACHINE ON CONDUIT CONSTRUCTION FOR THE WISCONSIN TELEPHONE CO., MILWAUKEE, WIS.

All paving is relaid, except asphalt, the relaying of which is done either by a contractor or by the city's asphalt-repair plant. There was considerable trouble in organizing the work, as the men were continually changing. With the much larger force required for handwork this trouble would have been greater. The use of the machines for trenching and tamping not only facilitated the progress of the work, but effected a material saving in cost as compared with hand labor. On this particular work the saving was about 60% on the trenching and 75% on the backfilling.

The operation of the trenching machine on the work above described attracted considerable attention from the officials of telephone and telegraph companies, and similar wheel-type excavators have since been employed on other conduit lines.

Concrete-Revetment Machine for the Mississippi*

By E. M. Markham†

SYNOPSIS—Large reinforced-concrete slab or mat is cast on sloping-deck barge. Barge is run up under trusses overhanging from power-equipped barge anchored with length extended into stream from bank to be revetted. Slab is attached to many lines hanging from trusses, and as mat barge is backed away the mat slides into water, each line taking load as its point of suspension reaches water. All lines released at once and mat, held at end to shore, drops to bottom. Continuous process of same sort "shingles" the subaqueous slope.

Some three years ago, after service of a year or more on the Lower Mississippi River Improvement under the Mississippi River Commission, the writer was aroused to the thought of the feasibility of developing a reinforced-concrete revetment to supplement or replace the willow fascine construction now employed. This thought was suggested primarily by the fact that the willow supply throughout the lower river is inadequate to meet prospective revetment needs; and secondarily by the obvious conclusion that a concrete revetment would be more effective and durable than a fascine structure, without necessarily being more costly. Again, the employment of concrete would result in an important reduction of manual labor and be capable of development by units in such manner that very desirable flexibility of organization and of output would be possible.

It was acordingly conceived that a scheme might be devised whereby large sheets of concrete, or of blocks, suitably disposed and secured, could be satisfactorily handled to appropriate position and relation upon the bed or bank to be revetted, with the result of a more durable, more efficient and more economical structure than now obtains. It was known that satisfactory and, from the nature of the case, inexhaustible deposits of sand and gravel for concrete purposes are spotted throughout the river and that a suitable river run product can be inexpensively dredged.

Presenting the matter for the consideration of the Mississippi River Commission, the latter allotted $2,500

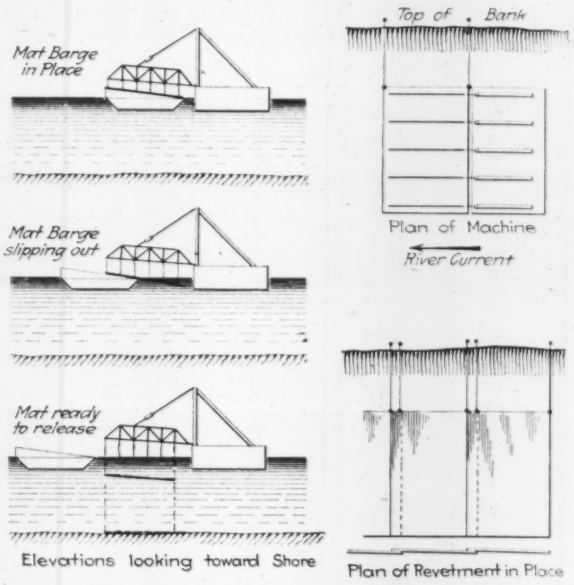


FIG. 1. DIAGRAMMATIC OUTLINE OF OPERATION OF MAT-LAYING MACHINE

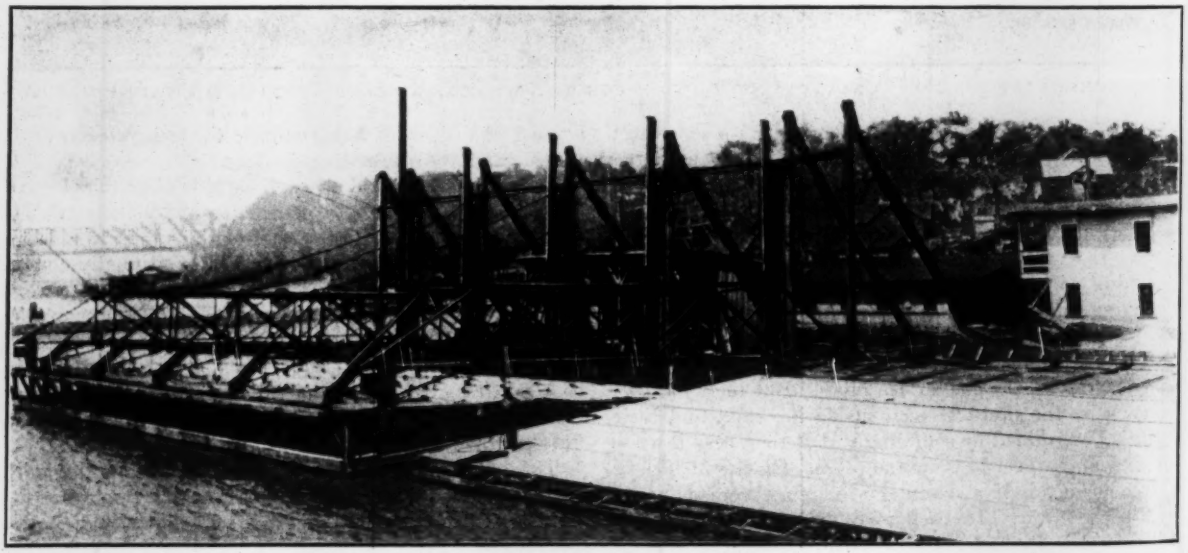


FIG. 2. VIEW OF EXPERIMENTAL CONCRETE REVETMENT PLANT BELOW MEMPHIS BRIDGE

*From "Professional Memoirs, Corps of Engineers, United States Army, etc.," November-December, 1916.

†Lieutenant Colonel, United States Army; Major, Corps of Engineers, West Point, N. Y.

for "experimental revetment" in the fall of 1914 and, based upon the results obtained thereunder, made a further assignment of $25,000 in the spring of 1915.

Under the allotment first referred to barges with inclined decks were prepared, upon which were formed and from which were launched eight concrete slabs, such control being provided as could be applied by lines handled manually. The smallest of these slabs were 14x18.6 ft., of which five were formed and launched; the largest were 100x40 ft., of which two were constructed; a fifth slab of intermediate dimension, 48.6x19 ft., was also employed. All slabs were 4 in. in thickness, reinforced by strand and mesh, variously clipped and wired together.

These slabs were handled somewhat crudely, the barges utilized being out of all relation to the problem; nevertheless, the results verified the thought that concrete sheets of large area and small thickness, heavily reinforced, can be considerably "man-handled" and directed to the river bed in such manner as to insure their effectiveness for revetment purposes. A diver, employed to investigate the condition of the two of the largest slabs, launched in inshore depths of 8 ft. and outer depths of 40 ft., reported the structures to be intact, subject to anticipated cracking, to be hugging the bottom closely and to be generally in very satisfactory condition.

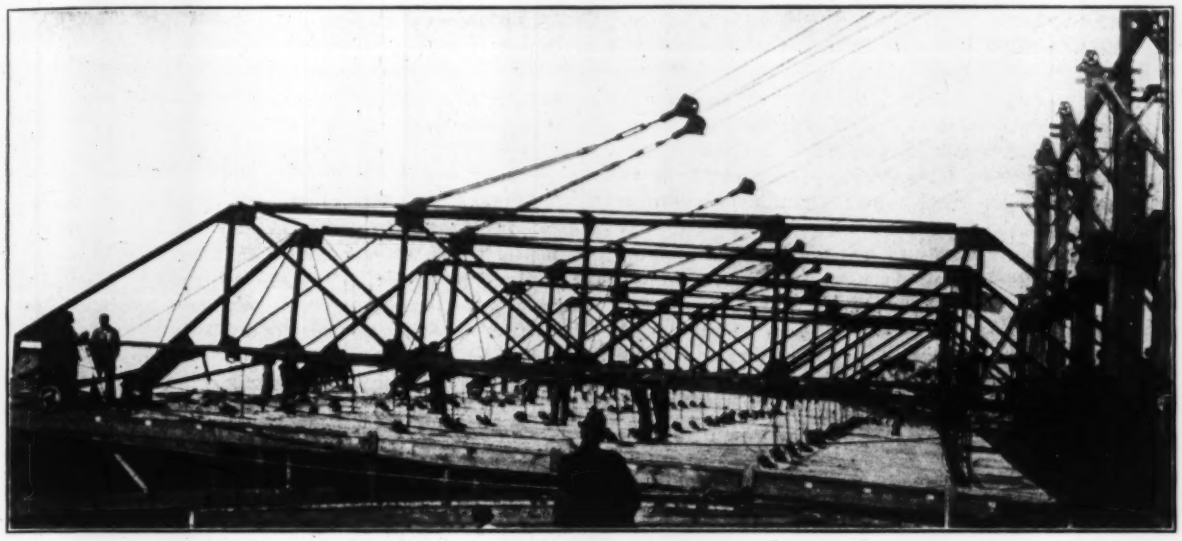


FIG. 3. CONCRETE REVETMENT SLAB JUST BEFORE BARGE IS SLIPPED FROM UNDER IT

Under the allotment of $25,000 for further experimental work, a plant was developed consisting of two barges upon which to construct concrete slabs or mats, and a third barge upon which were mounted the necessary machinery and structural work to handle the same from their position of formation to the bed of the river (Fig. 2).

The general proposition contemplated the formation of a concrete mat upon the inclined deck of a barge, the latter to be withdrawn under mechanical power after sufficient

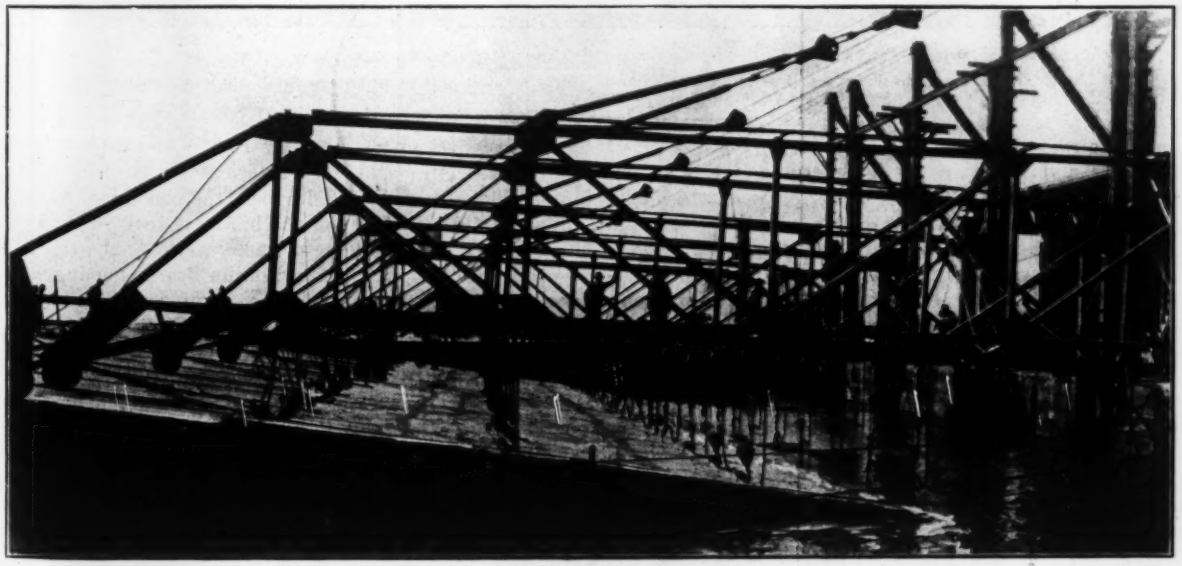


FIG. 4. SLAB SLIPPING INTO RIVER FROM BARGE

Note that chains at right are beginning to take up as slab goes under water

air hardening of the said mat, substitute support being simultaneously provided from a series of overhead trusses hinged upon a fixed mooring barge and having wheel bearings upon ways of the barge withdrawn. During and after withdrawal, this substitute support would be arranged for by a proper number, disposition and attachment of lines running from the overhead trusses to trigger or trip connections with rings or loops formed in the mat. A situation would thus be developed wherein the latter would be suspended as a weight in water, between mooring and mat barges, and might thereafter be lowered to position upon the supporting lines or tripped to freedom therefrom. After tripping, control and direction to position would be provided by shackle connections from the upstream edge of the mat by trolleys mounted upon mooring barge spuds or by upstream and shore cables. By resetting the mooring barge to accord with desired relation or overlap of successive sheets, a continuous interposition would be provided between the river and the caving bank under treatment. In other words, the caving bank would be "shingled" with large concrete slabs, or mats, each of such size and weight as to insure successful resistance against destruction by the hydraulic forces to which subjected. The slabs were to be reinforced with strand and mesh, such that maximum flexibility would be assured. Upon encountering check to their momentum in settlement toward final position they would crack into irregular areas and thus conform to whatever inequalities were involved. The several areas, however, would be held in juxtaposition by the embedded strand and mesh, ample virtue being thus retained for satisfactory compliance with revetment requirements. Subsequent undercutting or erosion would be closely followed, due to the deficiency of cantilever value, resulting from the relation of area to thickness, such deficiency to be additionally regulated, if need be, by the creation of planes of weakness of any desired position and number. Satisfactorily long life would be assured by the galvanization to desired degree of any or all the reinforcement. The principal strand of the latter would be extended upon the upper, or high-water bank, and securely anchored in its pavement. Such revetment would thus be essentially monolithic from top bank to deepest water. To provide for maximum plant capacity, an accelerator would be sought to hasten the hardening of the slab sufficiently to withstand launching, final hardening to continue, of course, upon the bed or bank revetted.

Experimental plant was designed to handle in the fashion described sheets 125x50 ft. by 4 in. Slightly lesser sizes have been employed as a matter of precaution and of convenience.

Details of the Equipment

The mat barges were provided with inclined decks subdivided transversely by ways on 8-ft. 4-in. centers, between which platform sections were so mounted upon supporting timbers as to be readily lowered or raised by about 4 in. In the raised position these platforms are flush with butter, or launching, boards about 11 in. in width, which

FIGS. 5 AND 6. DETAIL VIEWS OF PARTS OF THE REVETMENT MACHINE

Fig. 5—Lower end of slab, showing detail of supporting chain. Fig. 6—Near view of barge deck, showing rollers of truss supports and at right concrete slab disappearing into water.

themselves rest upon rollers inserted in the ways. After slab manufacture and upon sufficient air hardening, the intermediate sections are dropped, the concrete structure thus resting entirely upon the butter boards referred to. To launch a slab it is therefore necessary only to overcome the axle friction of the rollers, butter boards moving with the slab and being recoverable under proper provision for that purpose. The ways are steel shod to receive the wheel bearings of overhead trusses.

Mechanical and structural equipment, mounted upon a wood barge 124x30x7 ft. consists of 35-hp. boiler and double 7x7-in. engine, rigged with drums, winches, etc., of five intermediate trusses from which to suspend the slabs; and of two end trusses carrying sheaves and lines whereby to effect mat-barge manipulation. All trusses are hinged near the downstream edge of the mooring barge and have wheel bearings upon the ways of the mat barge. These trusses may be raised or lowered in unison through rigging to engine on the mooring barge, which as well

provides power through suitable lines for the maneuver and control of the mat barge during its withdrawal.

Suspension trusses are of five-panel point Pratt type, spaced on 25-ft. centers, the interval being subdivided by side stirrups from each main truss. All trusses are cross-braced and interconnected by rods and shapes. Suspension is assumed from each panel point of both main trusses and stirrups, and is accordingly on square 8 ft. 4 in. by 10 ft. Five supporting lines across the mat are thus available, each involving 15 suspension points. The supporting lines consist of ⅜-in. cable, end-wedged on outside trusses, passing thence through two fixed and one movable sheave above each suspension point to drums of a shaft located on the center truss. Lines from one side pass under and those from the opposite side over the said drums. Prior to launching, the lengths of these lines are fixed for support of the mat at desired submergence, the end brake of shaft thereupon set. As the mat relatively lowers during the withdrawal of the barge upon which formed, the supporting lines come successively into play, and the total weight to be carried is accurately and automatically distributed to the several suspension points, due to the character of the operation and to the fact that each suspension involves a movable sheave riding on a running line from center shaft to end trusses. No suspension, therefore, can assume more nor less weight than its due proportion. Under the arrangement described, the weight of a slab of 100 tons in air is necessarily so subdivided that the main trusses take each but slightly over 11½ tons, the suspension points somewhat less than 0.8 ton and the supporting lines but about 900 lb.

As a precaution against uncertainty or mishap involving the safety of the main plant, the strength of mat loops and of supporting lines is materially less than any element of the carrying structures. If, therefore, a trigger should fail to trip, or other untoward incident eventuate, the mat loop involved would part or pull or the suspension line break, before more serious result could develop.

The device employed at suspension points, suggested by the Bucyrus Co., of South Milwaukee, Wis., consists of a trigger attached to the housing of a movable sheave and carries a pin held by a spring in what may be termed a "locked" position. To "hook up" a mat for launching, this pin is withdrawn by hand sufficiently to pass the mat loop between the pin and the jaw. The trip device remains in the "locked" position during the operation of launching and while the mat is held in suspension. Connected to the tops of the several trigger pins are chains attached to the overhead trusses and of such length as to retain slack when the running suspension cables have taken weight, all chains being adjusted for as nearly the same amount of slack as practicable. To trip or release the mat from suspension it is therefore necessary only to throw the brake at the end of the shaft on the center truss, whereupon the weight of the mat itself overhauls all suspending cables, thus taking up the slack of all trip chains, whereupon the trigger pins are pulled practically simultaneously and the mat is thus freed from any connection to the overhead structures.

To withhold the mat from movement with the mat barge, during withdrawal of the latter, shackle attachments are made from its upstream edge to trolleys designed to travel vertically upon spuds of the mooring barge. The mat, upon being tripped, will therefore continue under control of its attachments to these spud trolleys, connection being severed at any predetermined depth by the withdrawal of shackle pins. Upon release from suspension, the mat may be controlled likewise by upstream and shore lines of appropriate number and anchorage.

To prevent the slab during barge withdrawal from tending to race off the latter, back hold lines are provided from attachments at its downstream edge to connections with overhead trusses near their wheel bearings.

Progress of Experimental Work

Eight concrete sheets or mats have thus far been constructed and launched. They were reinforced by ½-in. strand around the edges and on the lines of suspension and normal thereto; by $\frac{3}{16}$-in. strand running diagonally through suspension points, and by triangular mesh over the whole area. Both strand and mesh were variously clipped and wired together. Suspension loops were formed of ½-in. round iron in the shape of hooks of uniform height and were engaged about the lines of strand at their several intersections.

The first mat handled was 50x50 ft. by 3 in., weighing 62,500 lb.; the second was 122x47 ft. by 3 in. and weighed 215,000 lb.; the last six have been each 122x42 ft. by 3 in., weighing 192,000 lb. Width was reduced from 50 ft. to 47 ft., in order to provide a somewhat longer bridle from spud trolleys to upstream edge of slabs. It was again cut to 42 ft. in order to reduce overhang above the first line of suspension, which theretofore had caused objectionable droop of the upstream portion of the mat.

The transfer of slabs from the mat barge to suspension was accomplished without incident involving difficulty or trouble of any character. The general scheme, in this regard, would appear to be unexceptionable. Under proper lubrication of launching rollers, the mat barge may be withdrawn with an insignificant amount of power, moving in fact entirely under the influence of current and of the weight of the mat, once the latter is started.

The several slabs were launched over a shelving bank in inshore depths of from 8 to 18 ft. and outer depths of from 20 to 50 ft. All mats arrived at the desired position within reasonable limits of error, as indicated by corner lines.

Three slabs launched during a high river have been partly exposed to view at lower stages. They are to all intents and purposes intact, being cracked only to the extent necessary for their accommodation to bank inequalities, which are closely and satisfactorily followed.

It is conservatively estimated that, with reasonably resourceful management, one handling plant should dispose of five slabs or more per day of 10 hr. Expenditures upon the experimental work outlined have been such as to suggest for comprehensive work a probable field cost of about 60c. per sq.yd. A comparable figure for willow fascine construction is from 70c. to 80c.

Possibilities of the Method

It will be noted that the plant on hand was designed to handle continuous concrete sheets 125x50 ft., but that slightly lesser sizes were employed. The only case known to the writer where bank revetment requires an outshore dimension in excess of 125 ft. is on the lower Mississippi River, where, as stated, willow fascine mattresses are installed of a width of at least 250 ft. Concrete revetment in single sheets of this latter width is believed to be entirely feasible along the lines described, since the addi-

tional size involves no essential complication beyond the requirement of floating and other plant to scale, still within the limits of practicable construction and maneuver.

The launching, suspension and release of such slabs would not increase unit stresses in any element of the operation. Additional outshore dimension would simply be met by additional supporting trusses and suspension points, each carrying no more nor less than its due proportion. Similarly, no physical nor mechanical consideration militates against the handling of a slab exceeding the 50-ft. dimension, though a limit in this direction would soon be reached by reason of excessive mat-barge width, as well as the rapid increase of truss weights and stresses, due to additional spans. However, a slab of 50 ft. or thereabouts should be suitable and economical for the class of revetment involved.

The use of heavily reinforced concrete sheets after the manner described is not necessarily confined to bank revetment. They may be employed in any situation around or about the base of a structure to resist undercutting or erosion. Special arrangements for handling sheets in such situations would be required, the bulk of which, however, would doubtless be well within the field of reasonable resourcefulness and ingenuity.

Civil-Service Examination for Junior Engineer

On Oct. 11 and 12, civil-service examinations of candidates for appointment as Junior Enginer, Civil, Engineer Department at large, were held by the United States Civil Service Commission at different places throughout the country. As stated in the letter of General Black, Chief of Engineers, published in *Engineering News* of Sept. 28, those passing this examination are eligible to take the examination for appointment as Second Lieutenant in the Corps of Engineers to be held about the end of January.

The candidates for the examination on Oct. 11 were required to be over 20 years of age, graduates in civil engineering from a technical school of recognized standing or a senior student in such a school within six months of graduation, or else to have had at least four years' responsible experience in civil engineering.

The questions used in the examination, as reported to *Engineering News* by one of the candidates, were as follows:

Time allowed, two days of six and three hours respectively. The first two subjects will be given on the first day and the third subject on the second day. Candidates are allowed to use a slide-rule.

Subjects of examination and relative weights of subjects on a scale of 100: Pure and applied mathematics, 20; use and construction of instruments and surveying, 30; design and construction, 25; training and experience, 25.

MATHEMATICS

Answer five questions.

1. A man stands on a platform which ascends with uniform acceleration 6 ft. per sec. per sec., and at the end of 4 sec. after the platform began to move he drops a stone. Find the velocity of the stone after 3 sec.

2. The pressure of the water in a hydraulic company's main is 750 lb. per sq.in. and the average flow is 25 cu.ft. per min. What horsepower does this represent?

3. Find the length of a steel bar of a specific gravity of 7.8, supported vertically, which will break of its own weight. Ultimate strength of steel, 60,000 lb. per sq.in.

4. A uniform beam of a weight W^1 crossing a given span can bear a uniformly distributed load W^2. What load may be placed on the same beam if it crosses the span in n equal lengths supported by piers whose widths may be disregarded?

5. A 5-oz. ball moving at 1,000 ft. per sec. pierces a shield and moves on with a velocity of 400 ft. per sec. What energy was lost by piercing the shield?

6. Two plane mirrors A and B are placed vertically upon a horizontal table. A ray of light PB falls upon mirror B and is reflected to mirror A. Show that ray AQ reflected from the latter makes with PB an angle which is double the angle between the mirrors.

SURVEYING

Answer four questions.

1. Make a neat sketch of a Wye level mounted on a tripod. Make the sketch large enough to show all the outside details and name the parts.

2. (a) The following data cover a set of stadia survey notes and a table of horizontal distances and differences of elevation. Fill in the blanks in the set of notes by using the table and allowing for the instrument constant. (b) What is the horizontal distance between A and C?

Sta.	Az.	Inter.	Vert. Ang.	Hor. Dist.	Diff. Elev.	Elev.
Inst. at A						100.00
1	149° 20′	2.27	—3° 40′	.....	.....	.....
2	201° 15′	2.58	+4° 20′	.....	.....	.....
3	259° 45′	2.83	+7° 10′	.....	.....	.....
4	291° 18′	1.69	—2° 50′	.....	.....	.....
B	230° 10′	4.20	+5° 30′	.....	.....	.....
Inst. at B						
A	50° 10′	4.20	—5° 30′	.....	.....	.....
5	98° 38′	1.89	—1° 20′	.....	.....	.....
6	171° 47′	2.02	—4° 30′	.....	.....	.....
7	258° 18′	2.53	—8° 20′	.....	.....	.....
8	352° 48′	1.38	+7° 40′	.....	.....	.....
C	302° 23′	3.50	+2° 10′	.....	.....	.....
Inst. at C						
B	122° 23′	3.50	—2° 10′	.....	.....	.....

Stadia constant = 100

(Then followed a stadia table from 1° to 10° and for 10 intervals, giving both horizontal and vertical distances.)

3. Describe in detail and illustrate three good methods of locating soundings.

4. Rods are sometimes graduated to correspond with the stadia interval of a particular instrument. Describe in detail how you would determine the graduation for a rod in a case of this kind.

5. Name three methods of determining the discharge of a stream and describe one of the methods in detail.

DESIGN AND CONSTRUCTION

Answer four questions.

1. Describe the construction of a first-class brick pavement. Make a neat sketch showing the cross-section of one-half of the roadway and the sidewalk adjacent to it.

2. (a) Make sketches showing three different methods of splicing large structural timbers used as beams. (b) Show by a sketch how you would truss a 6-in. by 8-in. by 20-ft. timber beam with iron.

3. Make a longitudinal section of a square concrete box culvert 1 ft. thick all around to take care of a drainage area of 160 acres, showing a cross-section of a single-track railroad at that point. Top of rail to be 6 ft. about the top of the culvert, roadbed 18 ft. wide, slope 1½ to 1 and the ends of the culvert to be vertical and even with the intersection of the side slopes with the floor of the culvert. Show general dimensions. Given area of waterway = 0.8 acres.

4. (a) When it is necessary to lay concrete under water, how can it be done with good results? (b) When would you use the egg-shaped section for a sewer?

5. State the important details of construction of a heavy masonry dam.

Cable Street Railways, which came into extensive use in American cities to replace horse cars in the '80's and early '90's, but were superseded almost everywhere by the electric railway in the next decade, are still in extended use in San Francisco, Calif., and Edinburgh, Scotland. The cable lines that still remain in San Francisco are those which run on streets crossing the San Francisco hills with grades so steep that electric operation would not be possible. In Edinburgh, however, the entire city street-railway system is operated by cable. The Edinburgh system was built by the city in 1899 and leased for 21 years to a private company at an annual rental of 7%. The lease expires on June 30, 1919. The cars used are of small size and are operated at very low speed. The city plans to take over the system on the expiration of the lease and operate it by electric traction. A commission has reported in favor of operation by the overhead-trolley system, and the work of reconstruction is likely to be undertaken shortly, so that electric cars can begin running as soon as the lease expires.

Heavy Grading on 50-Mile Southern Relocation

SYNOPSIS—Striking items in 9,000,000-yd. grading on the Southern Ry. Very heavy excavation in four classifications. This 50-mi. relocation is heaviest of second-tracking between Washington and Atlanta. How the contractors are proceeding.

More than 30 steam shovels are at work grading a double-track line for the Southern Ry. from Central, S. C., to Cornelia, Ga. The present (single-track) line is 56 mi. long and serves Central, Seneca, Richland, Westminster, Madison, all in South Carolina, and Deercourt, Toccoa, Ayersville, Mt. Airy and Cornelia in Georgia. The new line, while touching at the present depots of the towns named, will cut down the distance 5.76 mi.; the curvature, 3,287° 17′; the vertical lift, 368 ft.

The work, which is very heavy, has been going on since spring and now is approximately 50% complete. The heaviest cuts and fills are as given in Table 1, printed

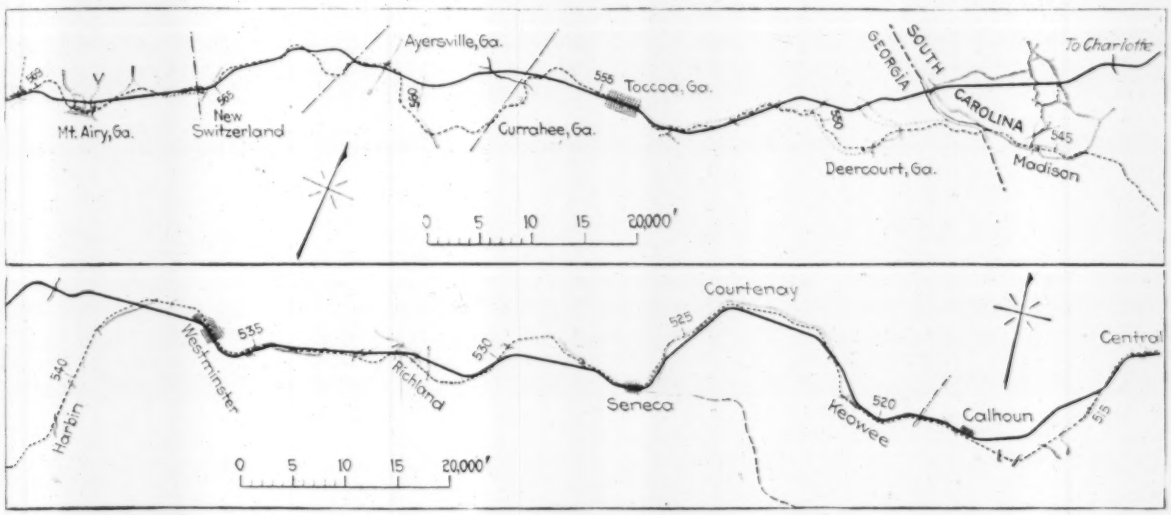


FIG. 1. RELOCATION OF SOUTHERN RY. FROM CORNELIA, GA., TO CENTRAL, S. C.
Old line shown dotted, new line full

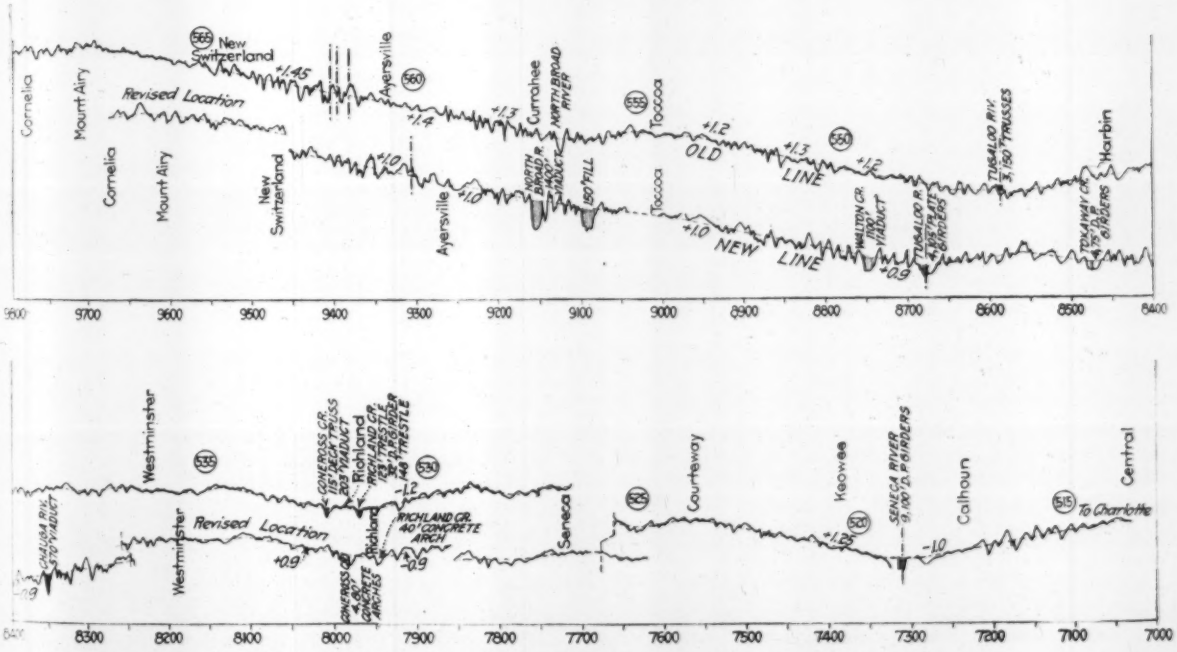


FIG. 2. OLD AND NEW PROFILE OF LINE WITH HEAVIEST GRADES

just below. The contract classification for material comprises earth, loose rock, soft rock and hard rock. The earth is a peculiarly light gritless material, easily handled whether wet or dry. The rock varies from disintegrated granite to blue granite and flint, with interspersing of mica. The grading was let in five sections to the contractors noted in Table 2.

TABLE 1

Station from Charlotte	Cu.Yd.
In Georgia	
9647–28	219,000 cut
9365–45	209,460 cut
9373–61	208,730 fill
9100–9083	1,500,000 fill
In South Carolina	
7940–21	103,100 cut
7858–29	256,870 cut
7830–7781	146,100 fill

TABLE 2

Contractor	Length of Section, Mi.	Cu.Yd.	Shovels at Work	% Complete
C. J. McKinney	12 5	774,000	5	63
Robert Russell	9 7	859,000	5	74
Winston & Co.	9 3	1,877,000	7	25
Rinehart & Dennis	6 2	1,667,000	5	40
C. W. Lane & Co.	5 5	2,750,000	8	21
H. S. Dunavant & Co.	7 2	1,011,000	3	32
Total	50 4	8,938,000	33	49

Where New Line Crosses Old

On the Rinehart & Dennis section, between Toccoa and Deercourt, Ga., the new line crosses the old at two points. Work is going on at one of these at the present time, and not a little annoyance was caused at first by hold-ups due to traffic on the main line. In one day there were ten stoppages aggregating 2 hr. 32 min., the longest being 50 min. One day 40 cars were blocked; on two other days 80 cars were held up per day. The narrow-gage tracks cross the main line on rails fastened to a turntable. To clear the main line all that is required is the removal of four pins, and a 10-ft. walk by a man to swing the turntable rails out of the way. When the work at this point is finished, the turntable will be taken to the other intersection and work will be started there. Six scrapers are doing the final grading.

North of the first intersection the old and new lines run side by side, the new being about 15 ft. lower. At one point the old roadbed is supported by a cross-tie crib.

The yardage on this section totals 1,800,000, of which 730,000 is borrowed for a fill 105 ft. high by 1,100 ft. long. The average height of this fill is 95 ft., while the average width on top is 60 ft. It is made from three parallel trestles of increasing height. Material is obtained from the hillside at three points corresponding in elevation to the several trestles. The fill will be pierced by a 30-ft. arch concrete culvert 300 ft. long.

The contractor has three shovels at work, the first served by 4-yd. cars, the second by 5-yd. The trains vary from 8 to 16 cars and are hauled by three 16-ton dinkeys, two 14-ton and a 12-ton. Two of the shovels started work the middle of May and have dug as follows:

	June	July	August
Cubic yards	30,000	28,000	35,000
Cubic yards	20,000	20,000	30,000

Of this, 25% was hard rock, 25% soft rock and the remainder earth.

One of these shovels is operated at night, because the material from it has to be hauled through a cut where another shovel works. It would be impracticable to haul the spoil from both shovels through this cut during the same working day. Carbide light is used.

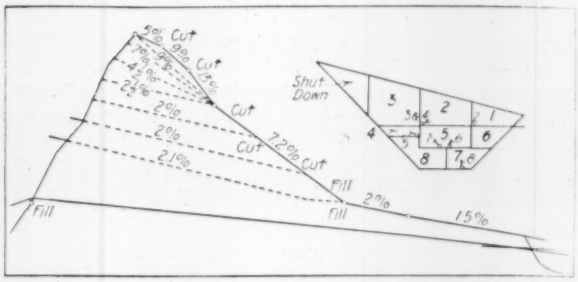


FIG. 4. OPENING ROCK CUTS ON SHEAHAN'S SUBCONTRACT

Right-hand sketch is cross-section showing shovel trips through hard-rock cut. Left-hand sketch is a longitudinal elevation showing method of excavating another cut. In order to start shovel at top of this second cut a fill had to be made on hillside as shown.

One of the fills is being made by "washing." A No. 8 Cameron pump having a 3-in. discharge lifts water 200 ft. through a 2,000-ft. pipe line. A rough trench was dug down the hill, and the water is directed into this through a 2-in. hose attached to the 3-in. line. The earth is light and is washed down to the fill. A small earth dam on each side of the fill retains the water until the earth settles. Two feet of clay overlies the light material in the hill and must first be washed away.

Two weeks sufficed to wash a cut wide enough for a dinkey track. The maximum depth was 20 ft.; the length was 400 ft. "The long pipe line and high lift reduced the water pressure to such an extent that the No. 8 pump used was not adequate," says the superintendent; but he adds: "With the right pressure this is a good way to move material of this kind."

The contract calls for the completion of this section by July, 1917. E. R. Faulconer, Superintendent for Rine-

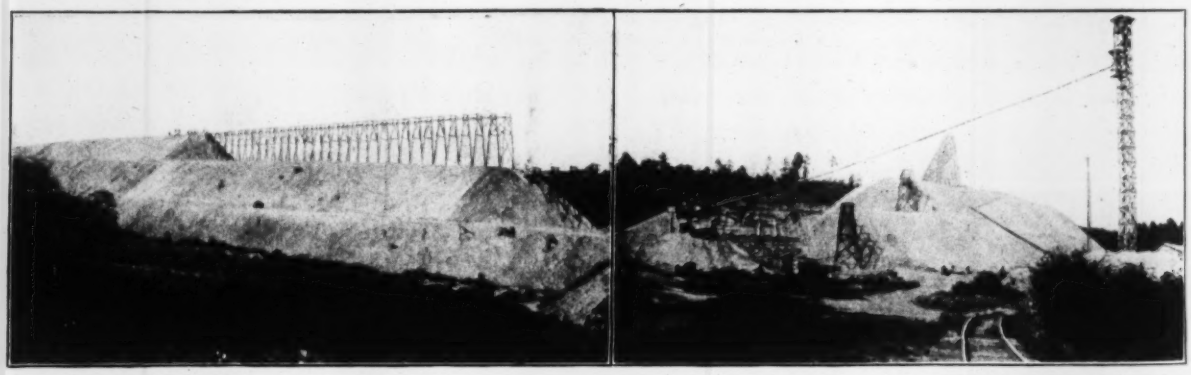


FIG. 3. TWO VIEWS SHOWING HOW 105-FT. FILL WAS MADE; CONCRETING 30-FT. CULVERT AT RIGHT

hart & Dennis, estimates that 3 mi. will be ready for the track gang by March. When the track is down and the old line relieved of traffic, two of the cuts will have to be made from 6 to 10 ft. wider. The rest of the section should be finished a few months later.

Hard Rock Chewed Up 17 Bits in Two Days

The Sheahan Construction Corporation, of Roanoke, Va. (sub-contractor for Rinehart & Dennis), has heavy bluff work midway between Toccoa, Ga., and the South Carolina-Georgia state line, a distance of about 1½ mi. and containing 650,000 cu.yd. of excavation.

Very little earth has been encountered, the material being loose, soft and hard rock. One of the first cuts started contained very hard blue granite underlain with flint and was exceedingly difficult to drill. No. 3 Keystone traction well drillers were used, and seven 5⅝-in. bits were required to drill through a stratum of flint 2 ft. 10 in. thick. Seventeen bits were badly damaged in drilling a single hole 22 ft. deep in 22 hr. Cyanide of potash was obtained in Atlanta for the purpose of case-hardening the bits, but there was little improvement. The drilling machines made the journey from railway to hill by their own power and went up the hill, assisted by two mule teams and block-and-tackle.

The holes were drilled about 20 ft. per lift in three lines 20 ft. apart, the holes in a line being on 15-ft. centers. After springing, the tamping was drilled out of the holes with the well drill, and three cases (300 sticks) of 60% dynamite were loaded into each hole. Much of the hard rock came out in large pieces, which were piled out of the way by a steam shovel (views 4 and 6 in Fig. 6) and later were drilled with "Jackhamers" and broken into sizes convenient for shovel handling.

The handling equipment on this work comprises two 2½-yd. shovels, six 18-ton Vulcan locomotives, sixty 4-yd. Western dump-cars, two Keystone drills and a steam-drill outfit.

In the beginning 12% grades were encountered, and two locomotives were required to haul two to four cars. As quickly as possible more cars were added to the trains. In the latter part of September the steepest grade was reduced to 7½%, and one locomotive could haul 10 cars. There was practically no light work, except drilling.

The first shovel started May 23, the second on June 1. The best record made by a single shovel was 40,000 yd. in August and 38,000 yd. in September, digging in earth, soft rock and boulders. The haul was about 2,000 ft. In August this shovel moved 12,000 cars, and 11,500 in September. In the rock cut the shovel averaged about 12,000 yd. of hard rock per month, working 11½ hr. per day.

Trestles up to 70 ft. in height are built to grade. For fills higher than 70 ft. the trestles are built 50 ft. high, filled in and the track jacked to grade.

Fill 150 Ft. High Instead of Viaduct

By far the biggest fill on the Southern Ry. is under way on C. W. Lane & Co.'s section, near Toccoa. This fill will be 150 ft. high, about 1,500 ft. long, 530 ft. wide at the base and will contain 1,500,000 yd. of material, a large part of which is borrow. The fill crosses the present location of the main line at an angle of 60°, and the top will be 82 ft. above the old grade.

When the line was laid out, it was proposed to erect a steel viaduct at this location; but the high cost of steel caused the railway company to decide in favor of a fill. An arch concrete culvert has been built under the fill, and the fill itself had been carried up about 60 ft. by Oct. 1.

In making the fill the first important operation was to build an 18-ft. dumping trestle. After this had been filled, the work was carried up by jacking the track and throwing it over, as required. Two 3½-yd. steam shovels supply 12-yd. air-dump Westerns drawn by

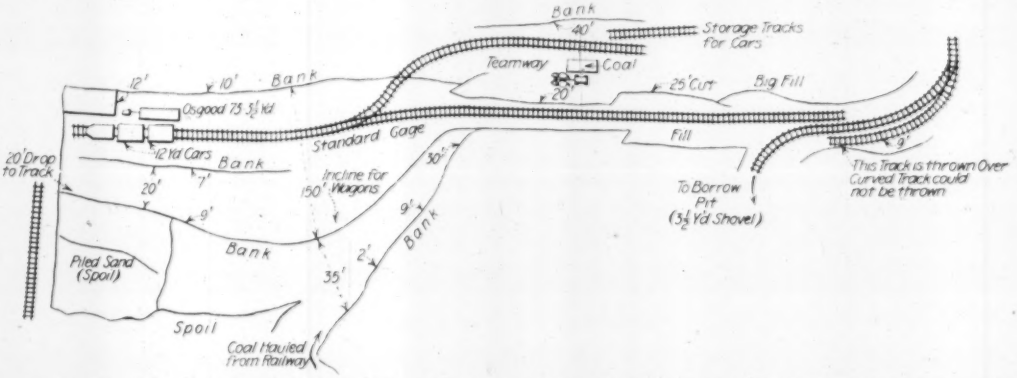


FIG. 5. PLAN OF BIG FILL AND BORROW PITS ON C. W. LANE & CO.'S SECTION, SOUTHERN RY. RELOCATION

standard-gage locomotives having six driving wheels, the middle driving wheel on each side having no flange. These locomotives are too long for the curves encountered and derailments have been common. It is the intention shortly to place flanges on the middle driving wheels. As an example of the difficulty, one morning four locomotive derailments occurred in as many trips from shovel to dump.

Observation of the work at this particular point leads to the conclusion that, while the heavy standard-gage engine with large wheelbase has undeniable advantages in main-line work, it cannot give its best service on the crooked and undulating construction tracks common to new work.

The heavy grade leading to one of the shovels necessitates a two-car train. Four-car trains run from the second shovel, one every 15 min. when all is well. Fig. 5 is a plan of the fill and adjacent borrow pits. The track running out on the fill from the borrow pit cannot be jacked and thrown over, on account of the curve in it. A switchback is therefore provided on the fill. A train from the second shovel runs the full length of the fill,

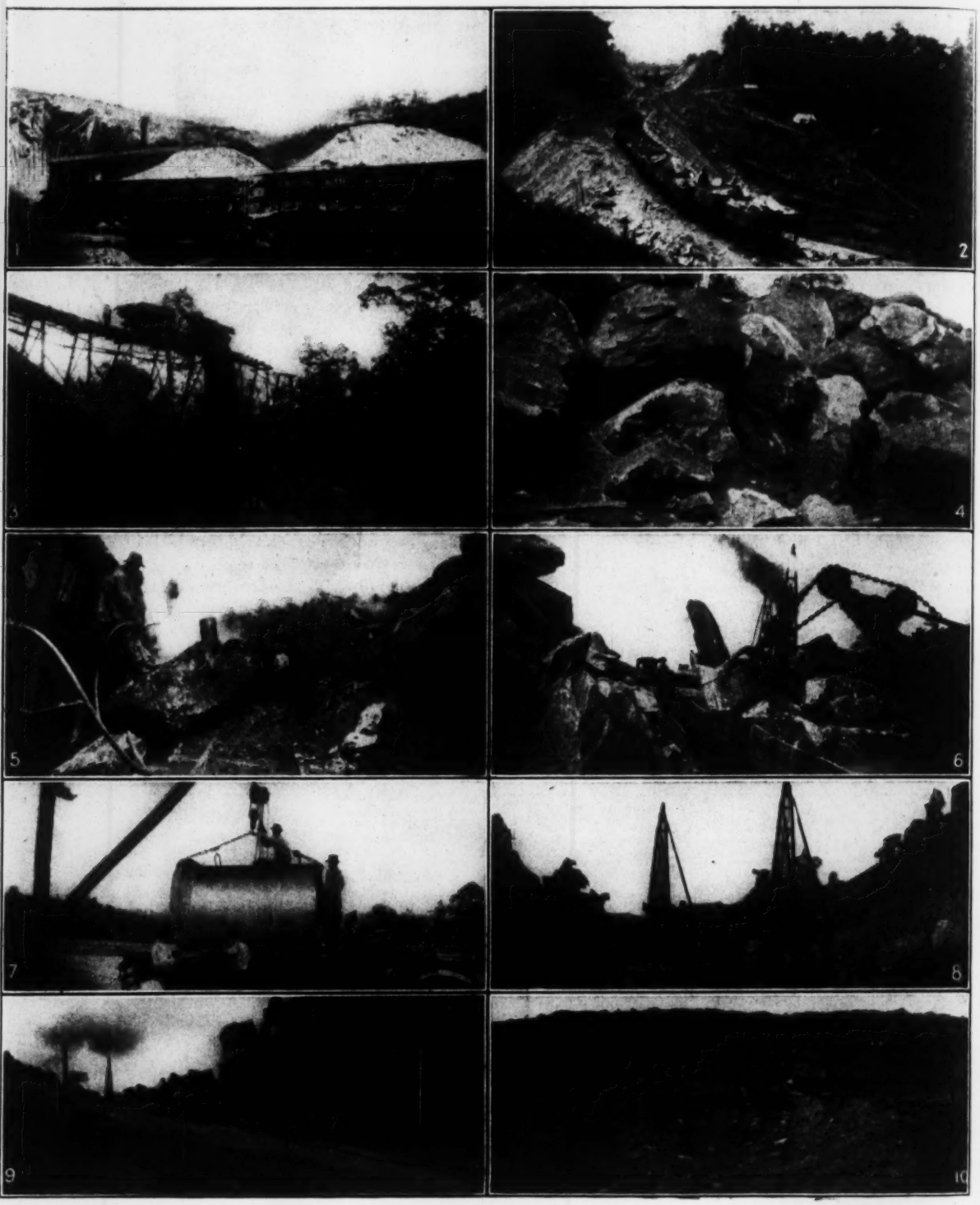


FIG. 6. HEAVY HANDLING IN GRADING 50-MILE SOUTHERN RY. RELOCATION

1—Shovel with 3½-yd. dipper loads 12-yd. air-dump cars on C. W. Lane's section. 2—One of Sheahan's trains of 4-yd. cars making a high fill. 3—Dumping 4-yd. cars from a 50-ft. trestle; cars sent out on trestle by thrust from dinkey, and are recovered by cable. 4—Large rocks piled temporarily by shovel. 5—Breaking up these rocks by drilling and shooting; drills take steam from dinkey boiler. 6—Shovel loading the broken rock into 4-yd. cars. 7—Few men required to load large concrete pipe on Sheahan's work. 8—Well drills working ahead of shovel in rock cut. 9—Old Vulcan shovel handling 17,000 yd. of rock per month. 10—Spoil from the Vulcan shovel is hauled to this 5-acre waste dump. Yardage wasted here exceeds 200,000.

backs down on the outside track and dumps. It then runs down the fill and backs to the shovel.

This procedure is not conducive to extremely fast progress, but it appears to be the only one practicable under the circumstances, these circumstances comprising the jacking and throwing of track. Another method would be to erect a trestle, dump from it and widen the top of the fill to permit the erection of another trestle, and

repeat. The jacking method is slow. Its chief applications are to widen the top of a fill or to raise a fill a comparatively short distance.

Just over a hill adjoining the big fill, and on the new line, a 1-yd. shovel is digging its way through at the rate of about 14,000 yd. per month. The spoil is hauled by 12 Western three-mule wagons to a small fill 600 ft. north of the shovel. When the shovel started into this hill, the haulage was difficult and a mule snatch was necessary in order to pull the wagons to safety. The lift was 30 ft. in 100 ft. The wagons hold approximately 1¼ yd., and about 600 are moved in a 10-hr. day.

The digging was earth at first, but rock was soon encountered, making blasting necessary. As soon as the shovel digs through, a track will be laid for a long haul to the big fill. Some distance beyond the fill is a rock cut containing considerable blue granite, which is very difficult to get out. One of the slopes will be 200 ft. high. An Atlantic shovel is handling the material.

At Ayersville—6 mi. south of Toccoa—a 3½-yd. shovel is working in a long cut containing some rock. The spoil is transported in six-car trains of 12-yd. cars. About ¼ mi. south of Ayersville the new line parallels the old, the two meeting at a fill. Here a trestle has been built on the side of the old 70-ft. fill. Material is brought to this fill from the long cut, the cars being backed out on the trestle, which is not intended to carry a dinkey. The new fill will be about 10 ft. higher than the old. Below is a 4x4-ft. concrete culvert. The concrete materials are delivered on the old fill, by railway, and chuted to the bottom. The concrete is mixed by hand on a large board.

Old Steam Shovel Works Well

At the extreme end of Lane's section, and in sight of the well drills of H. S. Dunavant & Co., a very old 3-yd. Vulcan 70-C shovel is working in a 100-ft. cut containing considerable blue granite with mica. A Cyclone well drill puts down 35- to 40-ft. holes. In the granite it is usual to make 35 ft. of 5-in. hole in a day. In the soft rock five holes, 100 ft., are put down in a day. The drill pulls itself along by cable.

The shovel handled 26,000 yd. (50% rock) in August, and 17,000 yd. (90% rock) in September. It is possible that 75,000 yd. from this cut will be used on a fill to the north; if so, a trestle will have to be constructed across the main line. Otherwise, all the material from this cut is wasted on a 5-acre tract purchased for the purpose by the railway (see views 9 and 10 in Fig. 6). The material is hauled to the dump in 6-yd. Kilbourne & Jacobs cars drawn by 20-ton standard-gage saddle-tank dinkeys.

When the shovel has almost completed a trip through the cut, a track is laid behind the shovel. By the time it has finished its trip, the track is ready for quick backing to position for starting the next trip. During this second trip the track on which the shovel backed is used as a loading track for the dinkey trains. The shovel has been moved back a distance of 600 ft. or so and started digging in a period of 6 or 7 hr. It was turned around, by throwing the track, in one day. The Vulcan shovel loads cars on a 5-ft. bank.

About a mile south of Seneca, S. C., Hickey Bros. (associated with Robert Russell) are making a long fill having a maximum depth of 42 ft.—the heaviest fill on the northern end of the line. The material—rock and earth, the latter being borrow—is hauled 1½ mi. by two 6-wheel (driving) switchers, having a short wheelbase. The train consists of ten to twelve 12-yd. cars. Between the 2½-yd. shovel and the dump there are three passing tracks. With this plant as many as 279 cars have been moved in a day. Although the cut contained 300,000 yd., this was not enough to make the fill; hence the borrowed earth, which is obtained from the south end of the cut. Later the haul will be 2 mi. The material in the cut was about 75% blue granite and 20% soft rock.

Big Locomotives Handle Record Amount

Two lengths of trestle were still open in the fill on Oct. 1. One of these was several hundred feet long, the other less than one hundred. Suddenly it was decided to construct an underpass at the shorter trestle, which is located between the shovel and the long dumping trestle. In order to proceed with the filling of the latter the shorter trestle was greatly strengthened by the addition of bents, bracing and longitudinal stringers, so that the heavy loaded trains could pass over it without noticeable vibration.

The entire fill was made by dumping from trestle, being carried to grade by jacking the track. Ordinarily it would have been widened by throwing the track over, but a curve in the line made this impracticable. A Western spreader is used. It is pushed by a 50-ton four-wheel switcher, and this outfit passes over the reinforced trestle without danger.

At the Seneca depot the old and new lines converge, the new dropping about 5 ft. below the old several hundred feet south. Here, the cut has been made wide enough for one track. When this has been laid, it will be used for traffic, and the old track will be removed and the cut widened for the second track. At present the cut is so close to the existing track that a crosstie shows through here and there. The earth is firm, however, and no underpinning is used. The cut is from 10 to 20 ft. deep. Final grading on this strip was completed by three wheeled-scrapers, a plow and two snatch teams.

Double-Tracking Between Washington and Atlanta

The entire line of the Southern Ry. between Washington, D. C., and Atlanta, Ga., will ultimately be double-tracked. This work is now going on at numerous points. The grading from Atlanta to Cornelia is completed. The work from Cornelia to Central, S. C., has been described in this article. From Central to Spartanburg, S. C., the grading is finished, while from Spartanburg to Charlotte, N. C., a distance of 75 mi., no work has been done; but it is probable that contracts for this grading will be let next season. From Charlotte north, about 240 mi. of line has been practically finished; from Arrowhead north, 121 mi. has been completed, and 16 more will be finished by the end of 1917.

All this double-tracking work is under the supervision of W. H. Wells, Construction Engineer of the Southern Ry.; R. F. Ezzell, Principal Assistant Engineer, Charlotte, N. C. J. O. Parsons, Assistant Engineer, is in charge of the work between Central and Cornelia, his office being at Toccoa.

Irrigation Field Laboratory at Denver, Colorado

By R. B. Sleight*

Coincident with the establishment, in July, 1915, of a district office of the United States Office of Public Roads and Rural Engineering at Denver, Colo., arrangements were begun for a field laboratory for irrigation research. This plant is maintained by the Division of Irrigation Investigations for the purpose of studying from an engineering standpoint such subjects as evaporation from water and soil surfaces, percolation and movement of water in soils, maximum duty of water for standard crops and similar problems. It is to be a field laboratory of such size and kind that natural phenomena can be observed under conditions somewhat less artificial than has been the practice.

A tract of land was selected in South Denver. A 12-in. main of the Denver Union Water Co., from which the water-supply is obtained, runs along one side of the lot. Electric power is available; sewer connection is possible; two car lines into the city are 300 ft. away; and the land is within the delivery limit of the Denver firms from which supplies are purchased.

Contrary to what might be supposed from noting the facilities mentioned, the tract has an exposure equal to that of a prairie homestead. To the north the adjoining territory is only partly built up with a few low houses. The east, south and west sides are open for from ½ to 5 mi. The topography is such that one-half of the tract is practically level, while the other half slopes off rapidly to the south. A grade of 20% is possible on this slope.

Since the research work is nearly all carried on in the field, a small shop and record office is the only building that has been necessary. However, the experiments in progress during this first year have required the construction or purchase and installation of a considerable amount of apparatus. A standard instrument shelter of the Weather Bureau is in use at present for housing, in addition to the maximum and minimum registering thermometers, a Pische evaporimeter, a hygrograph and a thermograph for air.

Supplementary to the usual two readings a day, which is as far as the ordinary meteorological observations go, continuous records made by recording instruments are kept of relative humidity, temperature of the air, temperature of water in one of the evaporation tanks, rate of evaporation from this same tank, barometric pressure and wind movement as shown by one of the anemometers. Two anemometers are in use at the laboratory, one located near the ground and the other on a tower.

For this meteorological observation work standard instruments furnished by commercial instrument makers are in use with one exception. For recording rate of evaporation from the surface of one water tank the Hoff

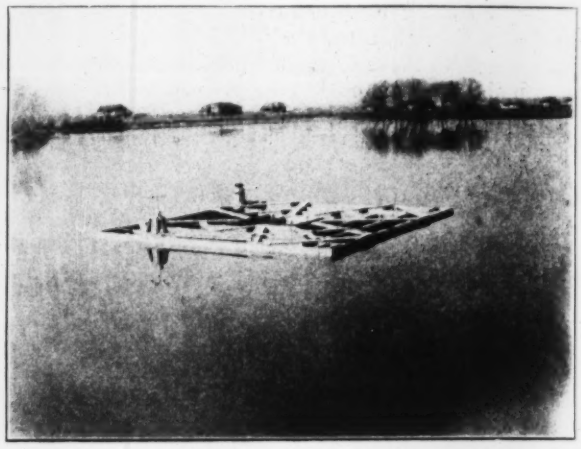


FIG. 2. FLOATING TANK FOR EVAPORATION EXPERIMENTS, WASHINGTON PARK

evaporimeter, designed and built by Edward J. Hoff, of the Division of Irrigation Investigations, is in use[1].

The equipment includes one mountain barometer, one barograph, one thermograph for air, one thermograph for water, one hygrograph, one anemometer register, three anemometers, five rain gages, one sling psychrometer, one reservoir psychrometer, eight registering maximum thermometers, eight registering minimum thermometers, six soil thermometers, three test thermometers and one standard thermometer. The instruments enumerated, and in

FIG. 1. GENERAL VIEW OF IRRIGATION FIELD LABORATORY AT DENVER, COLO.

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[1]Described in "Engineering News," Nov. 23, 1916, p. 974.

addition one or two standard types of water surface evaporation tanks—the type to be selected at the close of the present season's work—will comprise the permanent meteorological equipment.

The permanent shop equipment consists of such tools as are necessary for building, repairing and installing apparatus for any investigation in progress. Electricity is used for power and in the drying oven. The water-

FIG. 3. SAND SURFACE EVAPORATION TANKS, FORTIER TYPE

supply is piped to all parts of the tract where needed, with outlet connections every 50 ft. along the pipe lines. Throughout, the laboratory has been arranged and the equipment selected and installed in a manner so that research work may be carried on exhaustively and thoroughly, and still efficiently and at a reasonable cost.

Irrigation Experiments

During the season 1916 the experiments in progress are such as will form a basis for future research. They are: (1) An investigation of evaporation from water surfaces; (2) a study of evaporation from sand surfaces; (3) a

FIG. 4. FURROWS FOR TESTING FLOW OF IRRIGATION WATER

study of evaporation from the surface of the laboratory soil; (4) flow of water in small furrows.

Work on evaporation from water surfaces was begun as soon as possible after the establishment of the laboratory. The equipment in use consists of 26 water surface evaporation tanks and necessary gages for making measurements. These tanks range in diameter from 1 to 12 ft. and in depth from 3 in. to 6 ft. A floating tank station is maintained on one of the lakes in Washington Park, $\frac{3}{4}$ mi. from the laboratory. Provision is made for holding a set of tanks at different temperatures, and another set is equipped in a manner to allow a comparison between the evaporation from flowing water and a still body of the same shape and area. All tanks are of galvanized iron.

The equipment in use for the second experiment consists of a set of 28 double water-jacketed tanks of the type developed by Dr. Samuel Fortier for the study of losses of water from soil surfaces. These consist of an outer galvanized-iron tank inside of which is set a smaller inner tank containing the soil or other material to be used. The whole is set flush with the ground, and the annular space between the two is filled with water. The water jacket makes it possible to control temperature as well as facilitating the operation of weighing.

At the beginning of this investigation samples of river-bed material were secured from each of the principal

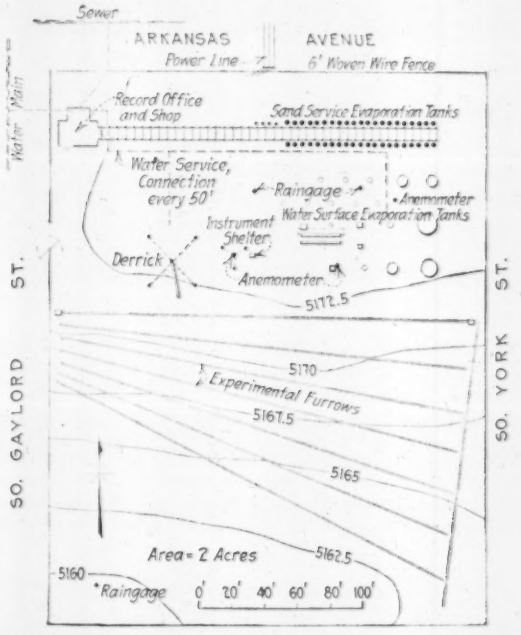


FIG. 5. PLAN OF IRRIGATION FIELD LABORATORY

Western streams. An analysis consisting of sieve separation and void determination was made of each of these samples. From the analysis certain type sands were selected for the purposes of the experiment. Tanks were filled with these type sands.

The water level in each tank is held at a certain fixed depth below the surface by adding water two or three times each day. The exact water loss under different conditions is arrived at by weight. A special swing hoist was designed and built for this weighing work. The lightest tank to be lifted and measured weights 370 lb. and the heaviest a little more than one ton.

It is hoped that the results from this experiment will present data from which to estimate the evaporation losses from the beds of such streams as the Rio Grande, the Platte and the Arkansas.

The investigation of evaporation losses from soils is being carried on in the same manner as the one on stream-bed material. It is the basis of more extended

work on water losses from irrigated lands and the deposition of salts in waterlogged or wet lands.

The south slope is being used for the fourth experiment of the season. Furrows were prepared on different grades, built to duplicate furrows used in the irrigation of orchards and row crops. Different heads of water, all small, were run in each of these in a manner to correspond with furrow irrigation. Data on the rate of flow, cross-section and grade have been obtained. It is hoped that the results will show whether or not the accepted formulas for flow of water in open channels can be extended to the very small ditches, as well as the flow in furrows. A view of this part of the field is shown in Fig. 4.

During the coming winter season the first work to be carried on under shelter will be started in the shop building. This will relate to the passage of water under pressure through different types of soils.

The Irrigation Field Laboratory is located at 1100 South Gaylord St., Denver, and forms part of the equipment of the Division of Irrigation of the Office of Public Roads and Rural Engineering, of which L. W. Page is director. The experiments have been planned and directed by Dr. Samuel Fortier, chief of the Division of Irrigation, while the writer has had much to do with the design and construction of the plant and has been in direct charge of the experiments from the beginning.

Concrete-Road Construction in Michigan

SYNOPSIS—This road was built alongside an interurban railway, which introduced drainage difficulties. Gravel concrete was used, and of special interest was the employment of machinery for floating the surface and placing the expansion joints. The plant and construction methods are described.

The concrete road between Royal Oak and Pontiac, Mich., has one side of the right-of-way occupied by the Pontiac double-track interurban line of the Detroit United Ry. This makes it impracticable to use the ordinary side ditches, so that special arrangements had to be made for

FIG. 1. REINFORCED-CONCRETE ROAD BESIDE INTERURBAN RAILWAY; ROYAL OAK TO PONTIAC, MICH.

carrying off surface water. The road has a heavy traffic of automobiles and motor trucks. The concrete road is 16 ft. wide and is built on an old gravel road. There is a 2-ft. shoulder of crushed stone on each side, and the inner edge of the concrete paving is in general about 6 ft. from the rail of the nearest track. The country is rolling, and in places there is a succession of grades of 3 to 6%, as shown in Fig. 1. Fig. 2 is a typical cross-section.

Drainage is provided for on the outer side of the road by an open ditch. On the inner side a drain of 4-in. vitrified tile is laid under the space between the road and the track, with iron-grated inlets at drainage points or sags.

FIG. 2. CROSS-SECTION OF ROAD FROM ROYAL OAK TO PONTIAC, MICH.

The joints in the tile drain are wrapped with tar paper to exclude the entrance of earth or other solid matter. Laterals of 12-in. vitrified tile are laid under the road and railway at drainage points.

The grading was heavy for ¾ mi. and light for 4 mi. After the old road surface had been sacrificed and the necessary grading done by a Thew steam shovel, the 16-ft. subgrade was well rolled with a 10-ton roller. Grade stakes for the concrete were then set at intervals of 100 ft. by means of a level, and intermediate stakes at intervals of 25 ft. were set by sighting over targets on the main stakes. Steel side forms were next placed. These were of the Baker type, 6-in. pressed-steel channels in lengths of 12 ft. supported by steel stakes.

The concrete is 8 in. thick in the middle and 6 in. at the side, the bottom being flat and the top crowned ¼ in. per ft. It is reinforced with a strip of American woven-wire fabric, 10 ft. wide, placed about 2 in. below the top surface and laid to within 6 in. of each expansion joint. These joints are of the Baker armored type, at intervals of 30 ft. An interesting feature was the placing of these joints by machine, as noted below.

The concrete is a 1 : 1½ : 3 mix. The coarse aggregate consisted of washed and screened gravel, graded from ¼ to 1½ in., while the fine aggregate ranged from ¼ in. down. At times the gravel contained an excess of the larger sizes, in which case the sand was increased to make a 1 : 2 : 3 mix, to insure filling of the voids. An unusual feature is that the concrete was made in a relatively dry condition, the working given it in the finishing process being relied upon to flush sufficient water to the surface. It was considered that a better and stronger concrete could be made in this way than by using a wet mixture.

One of the most interesting features of the work was the use of a Baker finishing machine. It consists of a transverse frame of steel beams, having its ends carried by wheels that ride on the steel side forms. It hauls itself ahead by means of drums having cables anchored ahead. The machine carries a templet, a compressing pan and a finishing float, all adjustable to the desired cross-section of the road and having an oscillating motion in a horizontal plane. The mechanism operating these parts and the cable drums is driven from a 3-hp. gasoline engine mounted on the machine.

As the machine pulls itself forward (at a rate of about 100 ft. per hr.), the rough concrete is first struck to the proper cross-section by the strike templet and is then compressed by the pan, which is set at a slight incline so as to press against the concrete, squeezing out air bubbles and excess water and filling all voids so as to make a dense surface. At the rear of the machine is the finishing float, which gives the final dressing and leaves a smooth surface. This machine weighs about 3,600 lb., and its surfacing parts exert a pressure of approximately 80 lb. per sq.ft. on the concrete. It is built by the R. D. Baker Co., of Detroit, Mich., which company uses it on its own work and also sells it to other contractors.

Behind the finishing machine was drawn a new joint-installing device that is being perfected by the same company. This consists of a frame carried on two truck wheels. It has a plate curved to the crown of the road and holding the Baker expansion joint. When it comes to the place for a joint, the plate is inverted, and by means of a slight sawing motion and vibration the joint is forced down through the green concrete.

Concrete Mixing and Placing

For the concrete road built in 1915 the gravel was delivered in drop-bottom cars on a siding of the interurban line and dumped into a track hopper from which a Weller conveyor carried it to a Stocker washing and screening plant. This plant had storage bins for 100 tons of sand and 100 tons of gravel. For the 1916 work, the gravel was obtained from a pit at Pontiac, where a Dull screening and washing plant was installed. The product was delivered to the storage bins by motor trucks, which ascended an incline of 6% grade, ran over the top of the bins to dump the material and then backed down.

From the bins the materials were delivered by chutes to the 1½-yd. steel dump-cars of a Koppel industrial railway of 24-in. gage. The railway was laid along the subgrade and was built with 16-ft. sections of track having light rails riveted to flat corrugated-steel ties. As the profile was very irregular, with grades of 3 to 6%, the trains of 10 cars were operated by a 13-ton Shay-geared locomotive. The materials were delivered in continuous stock piles along the work and were carried to the mixer by wheelbarrows.

The 16-cu.ft. Koehring mixer was equipped with a batch meter adjusted to retain each charge for 12 revolutions, or a period of about 45 sec. The machine traveled on the center line of the road and distributed the concrete by means of a drop-bottom bucket on a swinging boom that covered the full width between side forms.

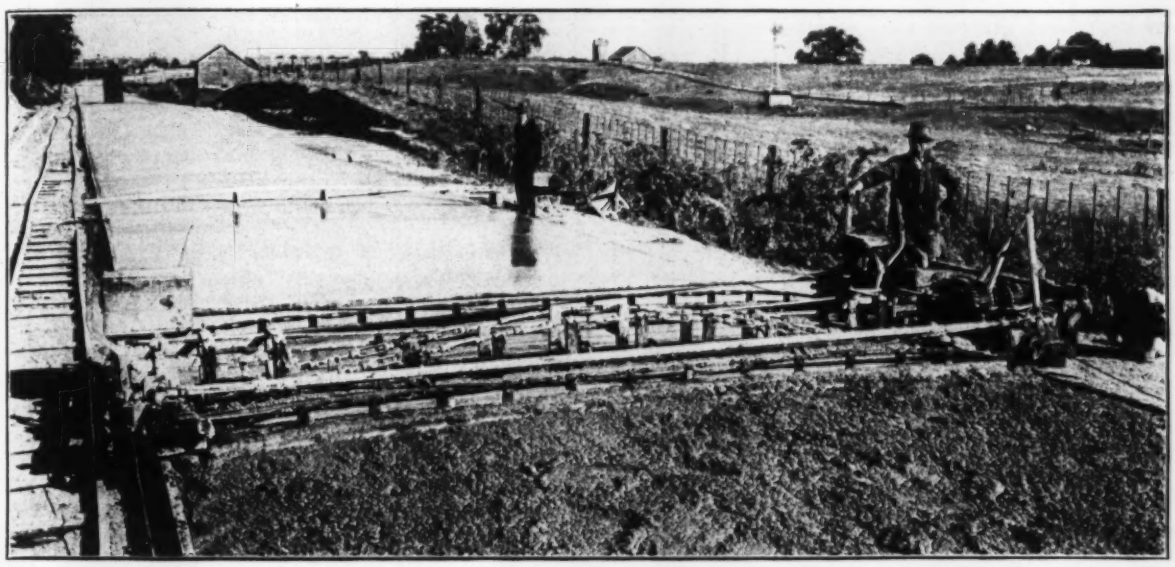


FIG. 3. THE BAKER MACHINE FOR FINISHING CONCRETE ROADS WITHOUT HAND FLOATING

The rough concrete in the foreground shows the comparatively dry mix used, the machine working the water to the surface as shown by the finished concrete in the rear. The bridge beyond the machine is for the hand floating at expansion joints. At the left is the industrial railway for distributing concrete material. This occupies the space for the stone shoulder of the road

With a gang averaging 30 to 35 men the work progressed at the rate of 450 to 600 ft. of road per day. The main part of the gang was distributed as follows: 1 on the steam roller, 3 with the material train, 2 trackmen, 12 wheeling material to mixer, 2 on the mixer, 3 spreading concrete, 1 operating the finishing machine.

The cost was about $13,500 to $15,500 per mi. of road. On half the work the grading cost $14.22 per 100 ft., and concrete cost $1.27 per sq.yd. On the remainder of the work these costs were $20 and $1.40 respectively. About 5½ mi. were built in 1915 and 4½ mi. in 1916. The R. D. Baker Co., of Detroit, Mich., had the contract for the entire work. The road was planned and surveyed under the direction and requirements of the State Highway Commission. M. De Glopper, County Engineer, Pontiac, Mich., represented the county during the construction of the work.

A City River-Control Reservoir and Plans for Operation

By completing its Milton reservoir on the Mahoning River, the City of Youngstown, Ohio, has acquired the distinction of possessing one of the few low-water river-control reservoirs in the United States—probably the only municipal reservoir of the kind on this side of the Atlantic. Frank M. Lillie, city engineer of Youngstown, has been in charge of the project from start to finish and will have the responsibility of planning the system of operation.

The reservoir is formed by a rolled earth embankment about 40 ft. maximum height and a concrete spillway of typical overfall dam section, 638 ft. long. Plans were shown and the construction described in *Engineering News* of Mar. 11, 1915, pp. 468-471. From the construction standpoint the distinguishing element of the dam is the upstream cutoff, a composite concrete and steel-sheetpile wall going 25 to 30 ft. down to rock, and the joining of this wall to the concrete paving of the upstream slope. The upper half of the upstream slope is paved with 18 in. of "riprap," which really is block-stone pavement, laid dry and then grouted solid with 1:3 cement mortar. The downstream face may be paved or sodded; the decision has not yet been made, but to simplify the maintenance work it is likely to be paved, either dry or grouted.

A new safety element has been added to the dam by detailing the concrete walkway on the top of the dam with a 24-in. concrete wall, 2 ft. high, along its upstream edge.

FIG. 1. DOWNSTREAM SLOPE, A SHORT SECTION PAVED

The concrete of wall and walk is carried over 18 in. deep to join the upstream pavement. The embankment now has the safety margin of spillway overflow depth of 11½ ft. (in place of 9½ ft. without the wall) and in addition the margin afforded by flow around the ends; the adjoining ground surface at both east and west ends is level with the embankment crest and therefore will spill water over a width of several hundred feet before the crest wall is overtopped.

No water has been impounded as yet. The four 60-in. conduits through the west spillway abutment are kept open, as the small present flow is needed in the river. The conduits have gate valves whose stems go up vertically to the top of the abutment and there have manual winch-and-gear mechanism for operation. The four individual gate chases are closed off toward the reservoir by bar screens extending from bottom to top of the abutment.

Two inches of runoff from the 300-sq.mi. drainage area of the reservoir will fill the basin. The spillway can discharge in 24 hr., at 5-ft. depth on the crest, an amount equal to 3 in. of runoff, and at 10-ft. depth nearly 9 in. of runoff. The spillway therefore is amply proportioned.

The volume of the spillway discharge is very great. At 5-ft. depth of overflow the discharge will be nearly 25,000 cu.ft. per sec., or 40 cu.ft. per sec. for each foot of length; at 10-ft. depth these quantities become 130,000 cu.ft. per sec. and 200 cu.ft. per sec. per lin.ft. Up to the present no artificial provision has been made to

FIG. 2. GROUTED PAVEMENT OF UPSTREAM SLOPE

take care of this flow below the spillway; the concrete ogee ends at the structural toe of the dam, and the dam has been so stepped off that the horizontal discharging surface is practically flush with the natural surface of rock.

The main use of the reservoir will be to increase the river flow at Youngstown, 35 mi. below, in order to make more water available to the steel mills for cooling purposes and in consequence obtain cooler and less polluted water at the city water intake, which is near the center of the city. As the consumption by the city had approached dangerously near the extreme dry-weather flow of the river, an increased supply was a necessity.

As matters stand now, in the summer months the river water is used five or six times over by the mills for cooling purposes before it reaches the city intake. The hope is that with the reservoir the low-water flow will be increased four or five times.

The reservoir is capable of supplying half the annual mean flow for a period of two months. Since the drainage area at Youngstown is about three times the drainage area at the dam, the amount of increase at Youngstown is considerably less.

Over how long a period the reservoir storage must be spread will have to be determined by judgment each season. To furnish a guide, equipment will be installed for routine measurement of river flow above the reservoir, discharge below the reservoir, and rainfall. Rainfall observations near the dam site were started a year ago. They will be continued at the operator's house, close to the east end of the dam.

It is expected that the routine records and the record of accumulated runoff will enable the city engineer's office to direct the gate operation prudently enough to utilize

the stored water with satisfactory efficiency. Some useful effect of the reservoir in reducing floods is, however, also looked for, as the high floods are nearly always springtime occurrences.

The reservoir is likely to be of scenic and recreational value. Real-estate development for summer cottages is already in progress. With regard to this and to boating, as well as the preservation of fish in the reservoir and avoidance of nuisance from exposed bottom areas, it is intended to fix a normal low-water limit for the reservoir, beyond which it would not be drawn down except in the extreme seasons. Such a limit must be decided upon before a storage and control schedule can be established.

The reservoir is under the jurisdiction of the Department of Public Service of Youngstown, under Harry Parroch, Director, and Frank M. Lillie, City Engineer. Its total cost has been about $1,200,000 to date, which will be increased slightly by cleanup work. Of this total, $243,000 represents the cost of real estate, and the rest is construction cost.

Combined Steam and Gas Power Station at Ford Plant

The plant of the Ford Motor Co. in Detroit, furnishing power for its shops, is one of the most novel and economical factory power stations to be found. It is described at length by Thomas Wilson in *Power* for Nov. 21, 1916, and from this article the following brief description is abstracted:

The combined gas- and steam-driven units were dictated by local conditions. The water-supply was insufficient for the condensers required with a steam-turbine installation; direct-current generators were advantageous for the shop drive; the combination units had gas engines on one side of the generators for economy and steam engines on the other side for reliability and regulation.

The engine units are arranged as cross-compound sets; there is a tandem compound gas engine on one end of the generator shaft and a tandem compound steam engine on the other end. There are at present four 6,000-hp. and one 5,000-hp. units; four more of the 6,000-hp. sizes are to be added. The generators are 250-volt two-wire direct-current machines. For the larger units the generators are rated at 4,000 kw.; for the smaller units, at 3,000 kw. The gas engines are of a four-cycle double-acting type with 42x72-in. water-cooled cylinders. The steam engines have 36 and 68x72-in. cylinders. The engines were made after the Ford company's design by the Hooven, Owens & Rentschler Co., of Hamilton, Ohio. The generators were made by the Crocker-Wheeler Co., of Ampere, N. J.

Ordinarily the load is carried as much as possible on the gas-engine side. At maximum load it is equally divided. The gas engine is connected to the governor of the unit, but it exerts no influence up to normal speed; above this it throttles both gas and air. The steam engine does the regulating and meets the load fluctuations. When the main circuit-breaker opens, the ignition circuit of the gas engine is opened and the gas throttle-control magnet closes—in addition to the regular action of the governor on the steam engine.

The various gas, water and steam circuits arranged for securing maximum utilization of heat are briefly as follows: Producer gas averaging 140 B.t.u. per cu.ft. is supplied to the gas engine; the exhaust passes through a water-cooled discharge line to superheating receivers between the high-pressure and low-pressure steam cylinders. Part of the gas from here is shunted through the high-pressure steam-cylinder jacket to maintain a temperature of 500° in the jacket. All the exhaust finally goes to the feed-water heater and is ultimately exhausted up through ejectors in the 207-ft. boiler stacks, increasing the draft for the boiler flue gases.

Cooling water for the gas engines comes in at 65° and leaves at 195°, going to an air-separating tank first and from there (as much as required) to feed-water heaters, pumps and the boilers. The excess, together with the condensate from the surface condenser, goes to the water-supply for sprinklers, cooling, etc.

Steam comes from the boilers (which are the largest yet built) at 175-lb. gage and 600° to the high-pressure cylinders (gas jacketed). From these it passes to the intermediate receivers (gas superheated) and thence to the low-pressure cylinders and the surface condenser. The condensate, as already noted, goes back to the water-supply. Eventually, if needed, the condensate may be used for boiler feed. The cooling water for the condenser comes from the general-supply pressure tank. In summer the cooling water is led from three ponds on an adjoining roof by gravity through the condensers to suctions of circulating pumps that force the water through the spray nozzles over the cooling pond. In hot weather one-half the water circulated is bypassed around the condensers and re-sprayed to increase the cooling effect. In cold weather the cooling water is circulated through a hot-blast heating system instead of the cooling pond. This heating system cools the water enough to give a possible 26-in. vacuum in the condenser, although a 20-in. vacuum is designed for ordinary operation. The power and heating requirements will ordinarily balance; but if the amount of steam should prove inadequate for the shop heating, small boilers can be used as boosters for the circulating water to increase its temperature before it goes to the blast coils.

Tests have not been completed, so that only estimates of the efficiency of the plant are possible. Taking the guaranteed and expected performances of the different parts of the system, it is estimated that 57% of the heat in the coal is utilized—20% in switchboard power and 37% in plant service.

Subsidence of Buildings in Cheshire, England, as a result of salt-mining operations, is described in a recently published book entitled "Salt in Cheshire," by Albert F. Calvert (Spon & Chamberlain, New York). According to the accounts in this book, Northwich, England, has suffered much more severely from subsidence due to salt-mining operations than is Scranton, Penn., from the coal mining carried on beneath it. Enormous deposits of rock salt underlie Northwich. At one suburb called Marston the salt is in places 182 ft. thick. In the early days of the salt industry in Cheshire, in the beginning of the last century, the salt was extracted by mining. To support the roof above, which was about 130 ft. in thickness, pillars were left 24 ft. to 30 ft. square at intervals of about 75 ft. Later on, the mines became flooded, and the bottom of the salt pillars was dissolved, removing the support of the roof. With the flooding of the mines, brine pumping replaced the salt mining. The subsidence that has taken place in recent years is due to the gradual washing away of the underground strata of salt. The companies pumping the brine are now compelled to pay a tax of about 5c. per thousand gallons, to provide compensation for property owners whose buildings are injured by subsidence as well as for those whose lands are submerged.

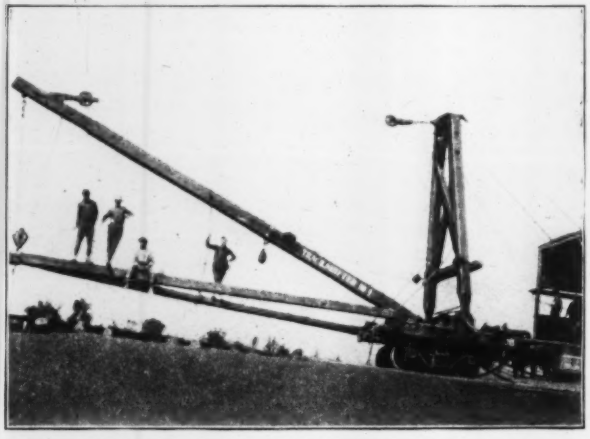
Notes from Field and Office

Machine rapidly shifts construction track—Surveying methods used in driving Strawberry tunnel—When jacks failed under a 400-ft. 700-ton bridge span; levers substituted—Charts for eccentric loading on rectangular areas

Machine Shifts 3,000 Ft. of Track in Half Day

At the Hill Annex iron mine at Gilbert, Minn., the dumps extend three or four miles, and there is a vast amount of stripped material to be handled, necessitating a constant shifting of track to the edge of the dump. The latter work was formerly done by hand, but a machine is now doing the work for A. Guthrie & Co., according to L. A. Rossman, of Grand Rapids, in *Engineering and Mining Journal*.

This machine is the result of several years of experimentation, as the contractors started to work on it several years ago when engaged in railroad operations in



TRACK SHIFTER FOR STRIPPING OPERATIONS

the West. A number of types were evolved, but the present one has given the best satisfaction. The contrivance resembles a wrecker in its general appearance. There is a boom about 40 ft. in length, and a wire rope, through pulleys, is fastened to the track for the purpose of lifting it up. On a level with the base of the machine is a side boom by which the track may be pulled sideways if desired. The operation is to attach the rope from both booms. The regular boom lifts to the required height, while the side boom is used to swing the track over to the desired place. There is one hoist of regular type and a horizontal boiler which furnishes the steam. The machine is self-propelled in the same manner as a steam shovel.

This device can throw a track over 6 ft. at a time, though the work must be done gradually to avoid either bending or twisting the rails. The method followed is to shift a track over 4 or 6 ft. and then move back 30 ft. and make a like move. The shifter has moved as much as 3,000 ft. of track a distance of 10 ft. in half a day, or more than 40 men could do in a whole shift. While the machine requires but few men to operate, it will do as much work as 40 or 50 men and was a great labor saver during the last summer, when common labor was very hard to obtain.

Tunnel Survey Methods Used in Driving Strawberry Tunnel

By L. M. Hammond*

The Strawberry tunnel, constructed by the United States Reclamation Service in connection with the storage works of the Strawberry Valley Irrigation Project, is located under the rim of the Great Basin, in Utah and Wasatch Counties, near Provo, Utah. The tunnel is about 3½ mi. long and is straight for its entire length. The finished section is 7 ft. wide by 8 ft. 6 in. high, with an arched top. About 3 mi. of the tunnel was driven from the lower or west portal, and ½ mi. from the upper or east portal. As Project Engineer, J. L. Lytel was in charge of the construction of the tunnel, while the engineering work was in direct charge of F. W. Cater, Assistant Engineer. Several other engineers, of whom the writer was one, were employed from time to time on the routine engineering work.

The profile of the ground surface along the tunnel line was such that only two intermediate set-ups were necessary between the two portals. Four large concrete monuments were therefore placed along the tunnel line, one just beyond each portal and one at each of the two intermediate points. The exact location of the line on these monuments was checked from time to time and was finally decided upon some time before the work was started at the east portal. Two independent "double rodded" level lines were run along the wagon road between the two portals, a distance of about 7 mi.; and as these checked by less than 0.10 ft., which was close enough for construction purposes, no further work was deemed necessary. The distance along the line (about 3½ mi.) was determined with a slope board. Two independent measurements gave results differing by less than a foot, and so it was not thought necessary to determine the length by triangulation. This work was done by the resident or assistant engineer in charge and one or two rodmen, as necessary.

Construction Line in Tunnel

The construction line in the tunnel was carried on screw hooks placed on the center line of the tunnel, either on wooden plugs driven into holes drilled in the roof, or on timber sets where convenient. These screw hooks were placed 50 ft. apart throughout the tunnel, and a new one

*Assistant Engineer, United States Reclamation Service, Provo, Utah.

was placed whenever the last one became 125 ft. from the heading. In order to facilitate the handling of muck-cars in the heading a section of double track, about 200 ft. long and with a switch at either end, was kept as close to the heading as possible. Hooks to be used as set-up points were set with special care at a point approximately in the center of this section. By setting the transit up in this particular spot it was possible to move empty muck-cars from a point ahead of the transit to the heading and back, leaving them (when loaded) on the other track, but still ahead of the transit. In this manner, construction work was not in any way interfered with, which is perhaps the most important feature of tunnel surveying.

A plumb-bob suspended from the previous set-up point and illuminated by electric lights if convenient, and by candles if not, served as a backsight, so that only two men were required for this work, one at the instrument and the other at the foresight. When the screw hooks were placed in plugs in the roof, there was practically no danger of their shifting; but when placed on timber sets, they had to be checked constantly, and it was customary after taking a backsight to check on one or two intermediate hooks before setting the new point ahead.

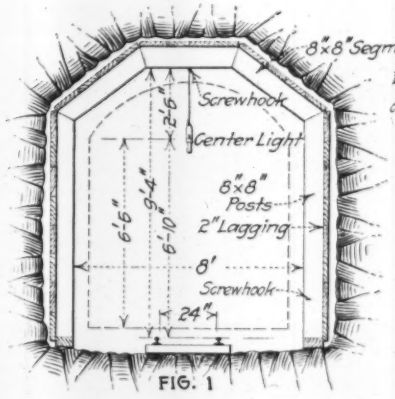
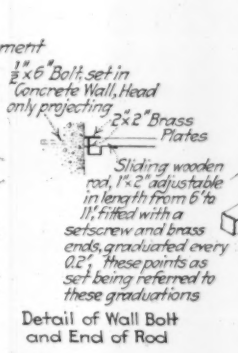


FIG. 1


1"x6" Bolt set in Concrete Wall, Head only projecting
2"x2" Brass Plates
Sliding wooden rod, 1"x2" adjustable in length from 6' to 11', fitted with a setscrew and brass ends, graduated every 0.2', these points as set being referred to these graduations
Detail of Wall Bolt and End of Rod

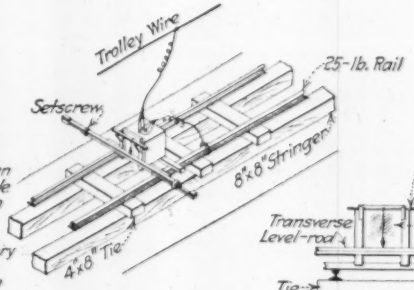
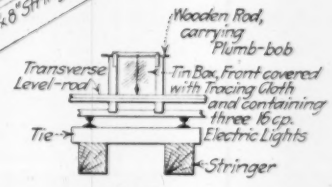


FIG. 2


Wooden Rod, carrying Plumb-bob
Transverse Level-rod
Tin Box, Front covered with Tracing Cloth and containing three 16 cp. Electric Lights
Tie
Stringer
FIG. 3

FIGS. 1 TO 3. SPECIAL SCHEMES IN STRAWBERRY TUNNEL SURVEY

Fig. 1—Sketch of location of construction-line points. Fig. 2—Arrangement for reading exact alignment on transverse level-rod. Fig. 3—Light-box

After the center screw hook had been set, levels were run, the elevation of the bottom of the hook determined and a grade hook set opposite the center hook and 1 ft. above true grade. This latter was to assist in laying track and placing timber sets. For the leveling, any convenient hook was used as a backsight, and for reasons explained above a sight was always taken on at least one other hook. In using overhead benchmarks it was of course necessary to use the level-rod inverted and to subtract backsights and add foresights.

The location of the center lights and their relation to the screw hooks and the neat lines of the tunnel, are shown in Fig. 1. The elevation of the screw hook once determined, it was an easy matter to adjust the length of the wire holding the center light (a candle stuck in a bushing) so as to bring the flame of the candle to the springing line of the arch. There were two of these center lights, one for each of the last two center hooks set. To avoid confusion a metal tag was kept fastened to the head light. This system of center lights was devised to give the shift boss or superintendent line and grade without the necessity of calling on the engineer at any time of day or night that he saw fit; and it made it necessary for the engineers to go into the tunnel only whenever a new center hook was necessary—at every 50-ft. progress of the tunnel, or approximately every third day. By hanging the two lights on their respective hooks the shift boss had a "line of sight" that would give both line and grade, sufficiently accurate for his purposes, at the face of the tunnel (or any other point) at any time. Having one fixed point, it was easy for him to "spot" the locations of the various holes to be drilled.

Control Line and Grade in Tunnel

Permanent benchmarks (for levels) were placed at various points in the tunnel, and the elevations of the construction points in the heading were checked up from one of these benchmarks at least once a month (from 300 to 500 lin.ft.). The elevations of the benchmarks were checked up occasionally from the portal benchmark. A 22-in. Gurley Y-level was used for all work, and sights were limited to 200 ft. and kept equal. While this instrument was somewhat heavy and cumbersome for tunnel work, the increased accuracy and its ability to hold its adjustments under somewhat trying conditions compensated for the inconveniences.

The apparatus used in checking the line is shown in detail in Fig. 2. For the first 2 mi. of tunnel, concrete monuments were placed at 1,000 ft. intervals along the floor of the tunnel and the line carried on them. At that point, however, a 7-sec.-ft. flow of water was encountered in the heading, which covered the floor of the tunnel with a foot or more of water and rendered useless all the carefully determined and preserved monuments up to that point. An entirely new system of marks was then determined upon and the line rerun several times.

Bolts were set in the concrete wall of the tunnel (or in the rock wall, if the tunnel had not yet been lined) about 1 ft. above the level of the water, with only their heads projecting. Three adjustable wooden rods were then made. The ends were capped with brass and had a small projecting brass lip (as shown), so that the ends of the rods could be made to rest upon and butt against the bolts on either side of the tunnel. The point was then determined on the rod. The rods were graduated to the nearest 0.2 ft., and the points as set were recorded as being so far to the north or south of any one graduation. It was thus an easy matter to take a numerical average of the

location of the various shots. The rods were numbered, and the same rod was always used at any particular station. The point as finally determined was marked on the rod, and its location was carefully noted, so that it could be restored if obliterated. As temperature and humidity were practically constant, expansion and contraction was negligible; and it was possible for a point, once determined, to be relocated in practically exactly the same place at any future time.

These "benchmarks" were located at 1,000-ft. intervals (there were 16 between the west portal and the point where the headings met). The foresight was always kept at 1,000 ft., and the backsight was varied between 1,000 ft. and 5,000 ft. according to conditions.

The greatest difficulty, of course, was in getting the line started into the tunnel. In order to avoid heat waves and condensation of moisture, it was necessary to select a time when the temperature inside and outside the tunnel was about the same, but even with the best of conditions it was necessary to take more than 100 shots on each of the first two points in the tunnel before results satisfactory to the observers were obtained. Once inside the tunnel the work was much easier, and from 8 to 24 shots were usually sufficient to determine a point with a fair degree of accuracy.

One of the hardest tasks connected with the engineering on any construction feature, and particularly on tunnel construction, where all the work is being carried on in a very narrow space, is to do the engineering in such a manner and at such times as to cause the least delay and inconvenience to the construction. The superintendent is almost always intolerant of delays, and it is hard to convince him that the engineers have difficulties as well as he. In this case the engineering work was done with practically no delay whatever to the construction work.

Inasmuch as the driving of the tunnel was carried on with three shifts, a great deal of time was lost in disturbing and readjusting the instrument and sights to allow the muck trains to pass. The concreting gang worked only in the daytime; and so this engineering work was done at night, as it would have been absolutely impossible to dodge both muck and concrete trains and still do any work.

Light-Box and Instrument

The method of supporting and illuminating the plumb-bob is shown in Fig. 3. It will be noticed that the plumb-bob, its support and light are entirely independent of the rod on which is the "monument," being supported on the tramway tracks.

Six men were always used on this work, two each at backsight, instrument and foresight. The men at the instrument and foresight took turns with their work, while the extra man at the backsight acted as messenger whenever necessary. Owing to the fact that the work was done at night, in long shifts, in a very wet and comparatively cold place and in a tedious and painstaking manner, it was exceedingly fatiguing to all the party.

The instrument used was a large Berger transit-theodolite. It gave excellent results and held its adjustments well. The instrument used in the construction work at the heading was a small Buff & Berger transit, which did very satisfactory work.

When the two headings met, it was found that there was an error in alignment of 0.18 ft., in grade of 0.13 ft., and in chaining of 2.5 ft. Considering the difficulties encountered and the fact that at no time was construction work interfered with, these results were considered satisfactory.

The methods and apparatus described are not exactly original with this tunnel, they being in some respects patterned after the methods used in the Gunnison tunnel, Colorado; neither can the changes and improvements be ascribed to any one man. They are an evolution rather than an invention.

Raising a Bridge by Levers When Jacks Failed

By W. T. Penney*

The ingenious plan adopted for raising the 640-ft. central span of the Quebec bridge from the scows to the final position reminds me of an emergency caused by the failure of the jacks used in jacking up a 400-ft. span weighing 700 tons.

In December, 1908, after unusually heavy rains, several bridges on the Costa Rica Ry. were washed out. The president of the road, Minor C. Keith (now president of the International Railways of Central America, which operates nearly all the lines in Central America), employed A. W. Buel, Consulting Engineer, of New York, to inspect the washed-out structures and make a report on their reconstruction. One of them crossed the Reventazon, one of the principal rivers in Costa Rica. As this river has a very rapid fall and often becomes a veritable torrent, it was considered unsafe to construct falsework for the erection of the new bridge. It was decided to design a 400-ft. span to be erected on shore and launched into position over a temporary cylinder pier erected in midstream. The span was designed to provide for the unusual strains occasioned by the manner of launching into position, as well as the strains due to the cantilever projection of half the span during launching. The end floor-beams were designed unusually heavy, as all the jacking in raising and lowering the span was to be done under them.

The span weighed 700 tons when erected and ready for launching. The permanent abutments consisted each of a pair of 12-ft. cylinders suitably braced together and filled with concrete. The temporary center pier was a pair of 10-ft. cylinders, braced transversely and guyed with steel cables to the launching abutments. In order to provide for the heavy bending moments in launching, double lines of plate-girder stringers 4 ft. deep were bolted to the bottom flanges of the lower chords, from end to end of the span, to fit roller tracks. The stringers used for this purpose were those permanently belonging to the span and 20 from another span still to be erected.

The available space for the erection of the span on the shore was limited. For this reason, when the erection—beginning at the outer end of the span, which rested on an inshore set of rollers—had passed the central panel of the span, the erection gantry remained stationary and the bridge was launched panel by panel from under it. The last-erected entire panel rested on the rear pair of rollers and the outer end on those placed on the first abutment. After the camber blocks were removed and the span swung, it had already been launched about a third of the way.

*Guatemala City, Guatemala, C. A.

Each truss was pulled forward by two luff tackles, operated by an estimated initial force of between 65,000 and 75,000 lb. Each tackle consisted of a pair of 20-in. triple blocks rove with 5/8-in. steel cable lines with a luff composed of a pair of 14-in. blocks rove with a 1½-in. manila line. The latter led to the winch heads of the erecting engines on the traveler; this made a steady, uniform haul.

The steel-cable tackles were secured at one end to loops of wire cable previously embedded in the concrete of the cylinder abutments for this purpose and for use in raising the traveler. The other end of the tackles was chain-hooked to the lower edge of the track stringers and moved back as the span advanced; thus all the work of overhauling the tackles was on the shore. A skidding track of 12x12-in. timbers was placed horizontally in the plane of each truss, between the launching abutments and the temporary rear roller pier. A transverse rail was bolted across the lower flanges of the rolling stringers, just before the latter left the rear roller temporary pier, so that it engaged the longitudinal rails and prevented any possible drop. A precautionary 4-ton counterweight of rails was placed on the rear end of the span, and it passed smoothly from the rollers to the skid rails. The writer suggested that a temporary pilot projection, about 10 ft. long, be built and bolted to the front end of the rolling stringers, so that when the center of gravity of the span approached the launching abutment the ends of the pilot engaged the fixed rollers on the temporary cylinder pier.

As there was a downgrade between the initial and final positions of the bridge, a heavy preventer tackle was provided to control the launching, but this was found unnecessary, as there was no tendency developed to move, except as the bridge was hauled by the luff tackles. The last 100 ft. of launching was assisted by a hoisting engine placed on the opposite side of the river beyond the abutment.

There being no anchorages available from which to guy the span transversely during launching, and some precaution against wind pressure being necessary, I moved the heavy erecting traveler to the best position for the purpose and blocked between the roller stringers and the traveler sills, spiking iron plates on the blocking and leaving a space of 1 in. With this arrangement, before the span could get out of line the traveler would have to move sidewise. When the launching was completed, I examined these plates and found them deeply marked from being in contact with the span, showing that the span had been forced back to position by its resistance.

When the span was launched, the end was jacked up to remove the roller bearings on the temporary center pier. It was supported on 7 ft. of blocking above the top of the cylinder abutment. The superintendent decided to raise the masonry 3 ft., to effect a reduction of the grade; even with this modification the bridge had to be lowered 3½ ft. The work was commenced with a number of 50-ton Norton jacks. Every precaution was taken to load these jacks uniformly, but three of them failed completely, and the remaining jacks were not sufficient to raise the load.

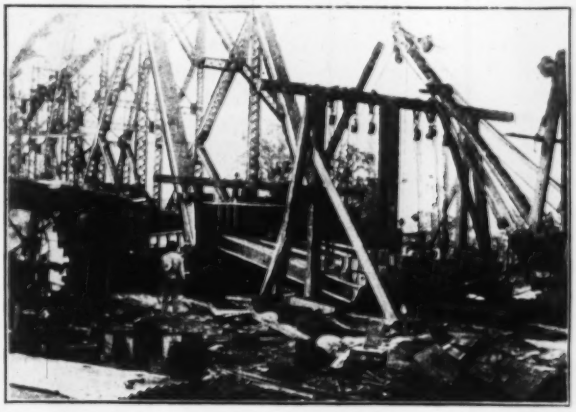
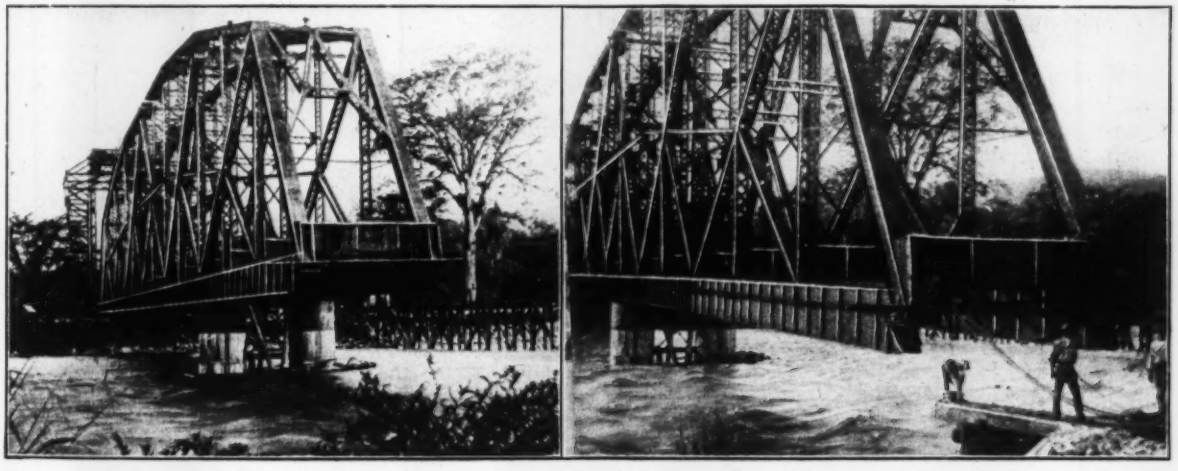


FIG. 3. LEVER RIG RAISING THE END OF REVENTAZON RIVER BRIDGE



FIGS. 1 AND 2. LAUNCHING A 400-FT. SPAN OVER A TORRENTIAL STREAM

To avoid delay an improvised method of lowering the bridge was devised by the writer and by the superintendent of bridges, R. Schutt, and was used successfully.

Four end posts of another bridge on the line, which happened to be available, were borrowed and used as levers. As these posts were 50 ft. long and weighed 6 tons each, they made serviceable levers. The short ends of the levers engaged the lower side of the end floor-beams. These beams had been reinforced for jacking, making them amply strong for the lever strains. In or-

der that these posts could be easily and quickly handled and in view of the short ends requiring little movement, they were supported by a steamboat ratchet, one end hooked to a timber placed across the span, the other ends to the levers. As the opposite ends of the levers had to be raised about 18 ft., they were operated by tackles from a bent placed for this purpose. This bent, built of 12x12 timbers, had a leg on each side of all the levers, thus virtually forming a slot for them to work in and preventing any side kick when carrying the load. As a further precaution against this danger the end of the span was cross-guyed with chains and steamboat ratchets. The heels for the levers were of sawn oak 6x12 in. by 12 ft. cross-piled, with fulcrums consisting of car axles laid on steel plates placed on top of the cribs.

The fall lines of the lever tackles ran to the winch heads of a hoisting engine. The ends of the levers were 18 ft. above level when finally placed. When all was ready, the levers were lowered and their supporting tackles overhauled. It was supposed that the weight of these immense levers would raise the span, but it never moved. There being a pile of boxes of rivets near-by, one box was placed on the end of each lever—it took eight boxes on each lever to raise the span, or 32 boxes in all; they must have weighed some 200 lb. each.

When the span did rise, it came up as easily as a pair of scales, the levers coming down on blocking already prepared for them. When the cribbing under the spans, consisting of rail ends 4 ft. long—afterward incased with concrete—was properly adjusted, the boxes of rivets were removed, one at a time. This operation was repeated for each 6 in. height of blocking to be removed. A total of 3½ ft. lowering was accomplished in 20 hr. The launching of the span occupied 10 hr., one-half of which time was consumed in overhauling and adjusting the tackles.

The scheme of erection was that of A. W. Buel in consultation with Minor C. Keith. Mr. Buel also designed the erecting traveler. The bridge was designed and fabricated by the Baltimore Bridge Co., H. D. Bush, Vice-President and Chief Engineer, H. W. Shaw and George F. Dilly, Assistant Engineers. The erection was done under contract by the writer. R. Schutt was Superintendent of Bridges and Buildings for the railway.

Charts for Eccentric Loading on Rectangular Areas

By S. M. Cotten*

The charts presented herewith give a graphical solution of the foundation-pressure formula $s = \frac{P}{L}\left(1 \pm \frac{6e}{L}\right)$. As usual, s is the pressure per square unit, P the vertical load on the foundation per unit of width, L the length of foundation, and e the eccentricity of P about the center of the foundation. The same units should be employed for L and e, either inches or feet, so that, if P be expressed in pounds, s is given in pounds per square inch or per square foot respectively.

The charts will cover any probable requirements of practice, but their scope may be infinitely broadened by remembering that it is entirely immaterial what units are used to express e, L, s and P, provided only that these are expressed in corresponding terms. For instance, if, when using the inch as the unit, a value of L greater than 60 is required, transform the given quantities into feet and

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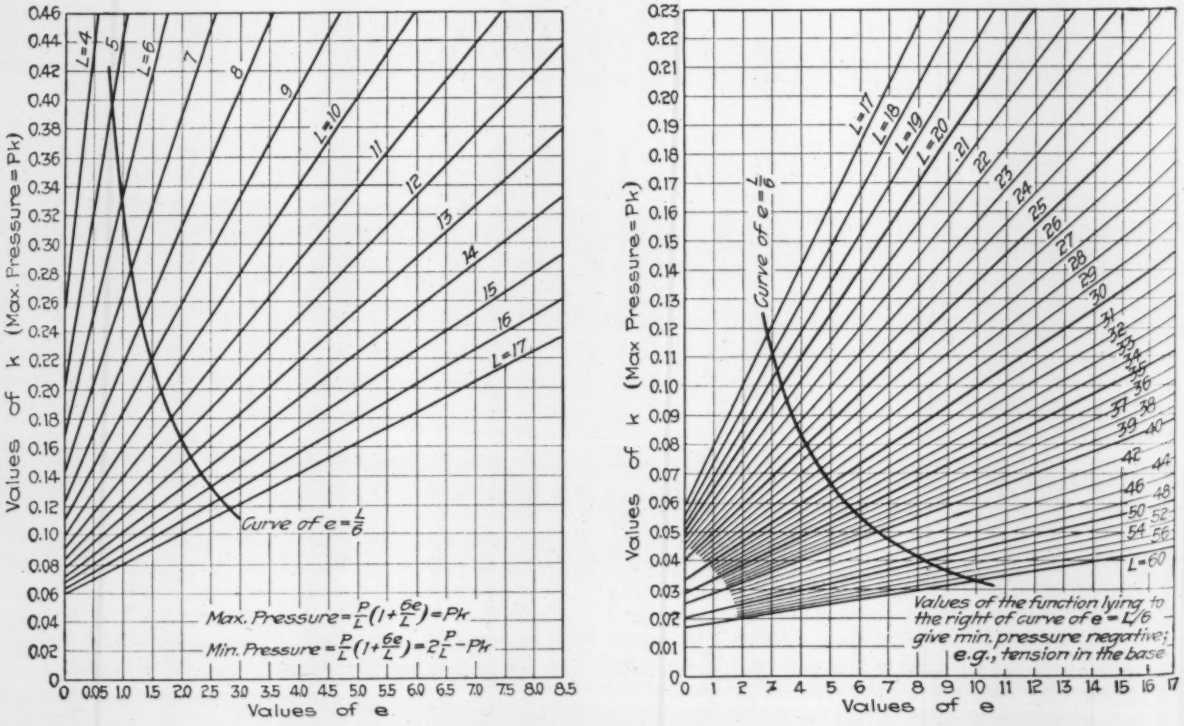


DIAGRAMS FOR PRESSURES ON ECCENTRIC FOOTINGS

pounds per square foot, which will give a value of L covered by the charts.

Since the function k given by the charts is the value of the maximum pressure, s_1, when $P = 1$, Pk will give the value of s_1 for any other value of P.

Use of the Charts

Given P, L and e, to determine the maximum and minimum pressures, s_1 and s_2. From the value of e shown at the bottom of the chart trace vertically up to an intersection with the line representing the given L; thence horizontally to the left, and read the value of k. Then, $s_1 = Pk$, $s_2 = 2\frac{P}{L} - Pk$. The value $2\frac{P}{L}$ can be read off at once, as it is $2\ Pk$ for $e = 0$.

Given P, e and desired value of s_1, to find the required length. Since $Pk = s_1$, $k = \frac{s_1}{P}$. Compute the value of k; enter the chart with this and trace horizontally to an intersection with the vertical representing the value of e; the required length lies on this intersection.

Given L, e, s_1, to find the maximum permissible load, P. Enter the chart with the value of e; trace vertically upward to an intersection with L; thence horizontally and read the value of k. Since $s_1 = Pk$, $P = \frac{s_1}{k}$.

The accuracy of the charts, to the extent indicated by the scales chosen, is assured by the fact that three values were computed and plotted for each value of L, the straight line representing this passing through all three points.

A few auxiliary facts that most texts appear to neglect may be worthy of mention.

To interpret properly the equation $s = \frac{P}{L}\left(1 \pm \frac{6e}{L}\right)$, it must be understood that this is merely a special form of the equation $s = \frac{P}{A} \pm \frac{Mc}{I}$, in which P is the normal load; A, the area to which P is applied; M the moment of P about the center of gravity of A; c the distance from the center of gravity to an edge of A; and I the moment of inertia of A about its center of gravity. When A is a rectangle, the latter equation reduces to the former.

If the distance d of the load from one end of the foundation is fixed, an investigation of the charts will show that s_1 is a minimum (and hence P, the supporting power of the foundation, is a maximum) when $L = 2d$. The variations in s_1 and P for $d = 6$ and various values of L are shown in Table 1. It will be observed that the values of s_1 and P increase and decrease respectively as L increases from $12 (= 2d)$ to 18, at which point the order is reversed. For $L = 18$, $e = L/6$ and $s_2 = 0$; hence for values of L greater than 18, s_2 is negative, giving tension in the heel. The formula assumes that this tension is an actual force or stress, as the tension area of a section of a loaded beam. Consequently, in the case of foundations, unless an equivalent tensile force is provided, as by means of anchor bolts, the values given by the formula, or the charts, for values of e greater than $L/6$ are not true. If the conditions are such that tensile stresses are not provided for, the maximum length, L', over which P may be distributed, is $3d$. Hence, when d is less than $\frac{1}{3}L$ (e greater than $\frac{1}{6}L$), $s_1 = 2P/L'$, and $s_2 = 0$. Of course, this consideration does not ordinarily enter into foundation design, it being an established principle that the resultant shall not cut the base outside the outer edge of the middle third.

A case that sometimes arises is: Given the vertical load and its eccentricity, to determine the most economical dimensions of the footing. The charts will show that the area required decreases as L increases. Table 2 shows a special case of the relative bearing power of the same area, for a fixed value of e, as L varies. Though a specific case, the conclusions therefrom are general; namely, that the minimum area to carry a given eccentric load will be given by making the length of footing as large as possible.

TABLE 1. FIXED EDGE DISTANCE OF LOAD

Showing variations in s_1 and P as L varies, the distance of the load from one end of the foundation being constant and equal to 6.

Values of L	Values of s_1 when P = 1	Values of P when $s_1 = 1$
7	0.448	2.2
8	0.312	3.2
9	0.220	4.6
10	0.160	6.2
11	0.115	8.7
12	0.083	12.0
13	0.094	10.6
14	0.102	9.8
15	0.107	9.3
16	0.110	9.1
17	0.111	9.0
18	0.111	9.0
20	0.110	9.1
22	0.107	9.3
24	0.104	9.6
26	0.101	9.9
28	0.097	10.3
30	0.093	10.7

TABLE 2. VARIATION OF PROPORTIONS OF THE FOOTING

Showing proportional carrying power of an area of 24, eccentricity of load of 3, as L and the width b vary.

Values of L	Values of k	Values of P when $s_1 = 1$	Values of b	Values of Pb
24	0.073	13.70	1.0	13.7
20	0.095	10.54	1.2	12.6
16	0.134	7.47	1.5	11.2
12	0.208	4.81	2.0	9.6
8	0.406	2.46	3.0	7.4

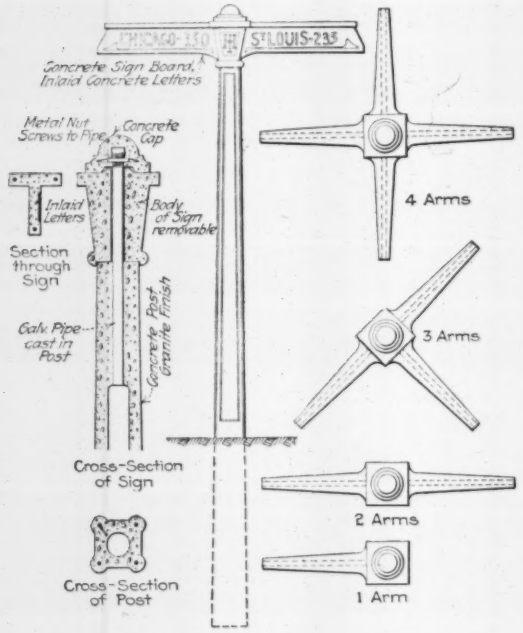
FINE AGGREGATE

Steel Must Be Inspected Before Shop Coat Is Applied—Clifford Older, Bridge Engineer, Illinois State Highway Department, Springfield, Ill., has just sent fabricators of bridge steel the following communication: "We believe it to be desirable that shop inspection of structural steel be made before the shop coat of paint has been applied. In the future, therefore, you will kindly notify us a sufficient length of time in advance of the painting of the fabricated steel, in order that our inspector may reach your shop previous to the application of the shop coat. In this connection I desire to call your attention to clause 359 of our 'General Specifications for Bridgework,' edition of July, 1915, which states in part that all parts which come in contact shall be painted with two coats before they are riveted together. In the future, failure to comply with this provision will be considered sufficient cause for rejection of the fabricated steel."

An Inverted Siphon on a Suction Pipe from a group of driven wells crosses the Des Moines River at Boone, Iowa, and is a part of the city's water-works system. The wells are on an island in the river, separated from the shore by a channel 200 ft. wide and about 12 ft. deep. The suction main is 800 ft. long from the wells to the channel, rising from 1.60 ft. above low water at the wells to 2.40 ft. at the edge of the island. Here an air chamber was provided by capping a cast-iron T 18x18x18 in. and dropping the main vertically to an elbow connection with the submerged pipe across the channel. The mainland end of the siphon terminates in a header about 4 ft. above low water, this header being located in a concrete pit 350 ft. from the pumping station. A 2-in. galvanized-iron pipe attached to the top of the air chamber is led down and along the siphon pipe to the pit, where it is connected to a wet vacuum pump. At low-water stages the siphon operates sometimes at 16 to 18 in. vacuum, corresponding to about 20 ft. hydraulic suction. The system has been in operation successfully since 1911. It was described by K. C. Kastberg, City Engineer of Des Moines (and formerly of Boone, Iowa), at the recent joint meeting of the Illinois and Iowa sections of the American Water-Works Association at Davenport, Iowa.

Curve for Design of Semicircular Flumes—The computation of the area and hydraulic radius for any given depth of water in a semicircular flume requires the use of somewhat long and complicated formulas. The accompanying curve gives the percentage of total area, hydraulic radius, or wetted perimeter for any percentage of total depth. The total area and the full-depth hydraulic radius for various diameters are generally given in the catalogs of the various flume companies or can be obtained from the "functions of numbers" tables in any handbook. The computation of A and r for fractional depths then becomes, by means of this curve and a slide rule, a very simple matter.—Lewis M. Hammond, Assistant Engineer, United States Reclamation Service, Provo, Utah.

A Road-Direction Sign that won the prize offered by the Illinois State Highway Commission last May (see "Engineering News," May 4, 1916) is shown herewith. The award was



PRIZE ROAD-DIRECTION SIGN

made to Walter H. Lienesch, chief engineer of the Universal Concrete Products Co., Chicago, Ill., for a concrete sign post and sign boards, in four units, all concrete except the galvanized pipe that holds the post, sign boards and cap in place.

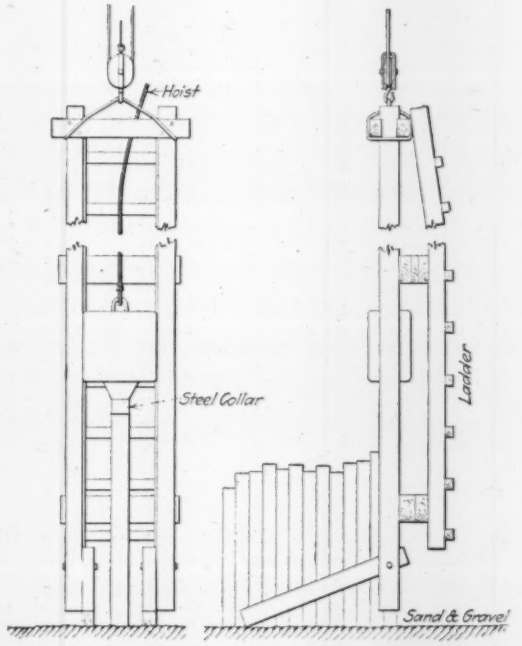
Rules To Govern Water-Main Extensions are recommended by J. A. Hiller, General Superintendent of the Water-Works Department of Cincinnati, Ohio, as follows: Property owners or others upon streets wherein no water mains have been laid and desiring the extension of water mains into such streets can have the mains extended upon the payment of 50c. for each lineal foot of main to be extended. This amount is to be considered as part payment for the main and is not to be refunded under any condition. The Water-Works Department is to pay the remainder of the cost of such extension. All parties tapping such mains and using water will be required to pay the regular water rates. The size of mains shall be determined by the general superintendent of the water-works. No mains are to be extended for a distance less than 48 lin.ft. No water mains will be extended in newly paved streets for a period of three years after the paving is completed. No water mains will be laid in streets unless the grade has been established and the surface is such as to make the work practicable.

Surface Finishing of Concrete Pavements—Very good results were obtained in finishing the concrete pavement constructed this past season on the Quogue-Southampton road, Long Island, N. Y., by the use of ⊥-shaped board floats about 6 ft. long and 12 in. wide. These floats were drawn back and forth crosswise of the pavement by workmen on bridges, as soon as the screeding had been completed. When not in use these floats were buried in order to prevent their warping. The width of the pavement finished with these floats was 20 ft.—H. T. Tuthill, Sayreville, N. Y.

A "Rag Method" of Finishing Concrete Pavement is described by S. P. Baird, engineer and contractor, of Columbus, Ohio, as follows: "I take a piece of ⅝-in. rope, preferably piece that is worn and pliable. The length of the rope is about 10 ft. more than the width of the pavement. To the rope are fastened pieces of cement sacks—that is, cement sacks slit into two pieces with the seams and hems removed, leaving a raw edge all the way around. These pieces of cloth are sewed to the rope along the narrow edge of the piece, the adjoining pieces overlapping half their widths. The rope with its attached rags is drawn over the newly placed concrete. To keep the apparatus in condition it should be cleaned once a day. The advantage I claim for this method over the garden-hose method, described in "Engineering News," Oct. 26, p. 803, and the canvas-belt method, described in "Engineering News," Oct. 5, p. 654, is that the finishing surface is wider than in the first case, and there is no puckering of the forward edge, as in the second case.

An Adjustable Grade Templet, designed to aid in laying mining and industrial tracks, is described by F. T. Teddy in "Engineering and Mining Journal." The templet is a yellow-pine plank 1¼x5 in. and 8 ft. 4 in. long, with the ends protected from wear by scrap-iron shoes, secured by countersunk screws, and having a vertical adjusting screw extended through one end. One of the straps is bent around the end of the templet and holds the nut of the adjusting screw. An inexpensive level bubble is fastened in a recess in the top of the plank by means of plaster of paris. In use, all that is necessary in order to establish any desired grade is to extend the adjusting screw through the necessary amount below the base of the plank. Thus, for 1% grade the screw is extended 1 in.; for a 2% grade, 2 in., etc. A screw that can be extended 3 in. is sufficient. Mr. Teddy says that he believes this method is sufficiently close for practical purposes.

Driving Sheetpiling with a Heavy Drop-Hammer—In constructing a 40-ft. concrete-arch culvert at Richland Creek, on the new Southern Ry. double-track line in South Carolina, wooden sheetpiling is being driven by an unusually heavy drop-hammer working in swinging leads. The hammer



DRIVING 24-FT. SHEETING WITH A 2,000-LB. DROP HAMMER IN SWINGING LEADS

weighs 2,000 lb. and falls about 17 times a minute, the drop being 6 ft. A wood cap with steel collar is placed on the pile to be driven, to take the shock. The penetration of the piling is 20 ft. The swinging leads were made on the job, and the sketch shows them in position over the line of piling.

Alloys for High-Pressure Fittings were discussed by S. D. Sleeth at the September meeting of the Institute of Metals. As a suitable mixture for ordinary castings such as cocks, pistons, bushings, etc., he gives Cu. 72.50%; Sn, 1.75%; Zn, 19.25%; Pb, 6.50%. For high pressures he recommends Cu, 82.00%; Sn, 7.50%; Zn, 4.75%; Pb, 5.75%, and Cu, 83.00%; Sn, 11.50%; Zn, 4.00%; Pb, 1.50%. These alloys are hard to machine.

Editorials

A Sound Court Opinion on Flood Prevention

Those who have engineered the Miami flood-protection project and the residents of the Miami Valley are alike to be congratulated on the strong, clear verdict of the Conservancy Court, printed in our last issue. Thorough and conscientious engineering work won a brilliant victory. During a judicial inquiry continuing for two months the methods and results of the engineers' studies were set forth in fullest detail and were dissected by the opposing counsel's cross-examination with every bit of legal skill and technical advice at its command. In both the initial presentation and the defense against attack, the "official plan" justified itself most convincingly.

The residents of the Miami Valley are brought measurably nearer to complete protection against the flood hazard. A great enterprise of pioneer character is put in the way of realization. The cause of flood protection, or let us say of stream control, receives a strong and needed impetus.

With the Scioto River flood-prevention project about to have its day in court, it is especially fortunate for the engineers and the people interested in the protection of Columbus that the Miami case has furnished so admirable a precedent. The court at Dayton delivered a truly judicial opinion. It dealt with the question on its merits and declined to be swayed by clamor and local prejudice, although before the decision there was much apprehension that the judges might yield to local pressure. The outcome justifies the expectation that Franklin County's judges also will deal with the Scioto protection plan on its merits. In that event the keen and careful analysis of the problem by the engineers will receive a well-deserved approval.

Earth dams are safe. The judges in the Miami case carefully and deliberately state their conviction of this fact. They reject the searching and persistent criticism of such dams, which the opposition put forward. Their opinion, formed after hearing elaborate evidence on every possible phase of this subject, is a salutary lesson to many an engineer.

Bridges are safe, though some bridges have failed. Buildings are safe, though wretched design and bad work made many a wreck. Dams are safe, though quackery and incompetence and neglect have brought about many a washout.

The judges did not ask: May not a weak dam fail? They were willing to venture their own lives and the lives and property of their neighbors on the assumption that good dams would be built. And assuming good dams, they declared that the dams *would be safe and of sufficient strength to sustain at all times any burden that may be placed upon them* by impounded water. Many an engineer can study with profit this calm and deliberate statement made by laymen after weighing the merits of affirmative and negative in a lengthy battle of fact and opinion.

Not less important is the court's declaration that retarding dams combined with channel improvement furnish for the Miami Valley the only practicable and complete protection from floods. Again there is opportunity for reflection by engineers. Flood prevention by reservoirs has been under a cloud—and for that matter is today under a cloud, and with good reason. The proposal to provide empty space for flood water and yet keep that space full of water for other use has proved very difficult to defend. But temporary impounding of flood waters, applied with patiently calculated precision and properly adjusted to the other variables of the problem, can accomplish the best and cheapest flood control for the Miami Valley, for the Scioto Valley and perhaps for some other locations. This is a new fact.

That retarding basins are not a cure-all, that special physical conditions must exist in order to make them efficient and economical, will be recognized as soon as a study of their peculiarities is begun. Warnings against oversanguine expectations concerning retarding basins are therefore little needed. The fact of present importance is that retarding basins have been proved to be in certain cases a very important agency for flood protection.

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United States the World's Reservoir of Capital

In a recent address before the Merchants' Association of New York, L. F. Loree, President of the Delaware & Hudson R.R., presented a summary of the international financial transactions of the United States since the beginning of the war. Mr. Loree is not only eminent as a railway president and a civil engineer, but he is a financier of international reputation. During the past two years he has collected statistics showing the extent to which American investors have repurchased American railway securities from foreign holders. These figures, in connection with the official statistics of the exports and imports from the United States and the floating here of foreign loans, enable a balance to be struck.

As everyone knows, the export trade of the United States has been increasing for the past two years by leaps and bounds, while the imports have remained about normal. In the last three fiscal years ended June 30 the United States has exported goods in excess of the value of the imports as follows:

1914	$470,653,000
1915	1,094,420,000
1916	2,135,775,000

This makes a total of over $3,700,000,000 as the value of the goods which the United States has sold to foreign countries in the past three years in excess of the value of its purchases from them. International trade balances are commonly settled by the export of gold, but it is impossible to settle any such vast trade balance by transfer of the precious metal. The entire stock of gold held by the four great government banks in Europe—those of Great Britain, Germany, France and Russia—was only $2,600,000,000 on Aug. 1, 1916, practically the same

amount that they held two years earlier, at the outbreak of the war. Official figures for gold exports and imports show that whereas in 1914 the United States sent abroad $46,000,000 in gold, in 1915 $25,000,000 in gold came to this country, and in 1916, $404,000,000. The bulk of the payment for the vast exports from the United States has been made not in gold, but in securities. Mr. Loree finds that between Jan. 31, 1915, and July 31, 1916, American investors purchased from foreigners over $1,288,000,000 worth of American railway securities. The amount of other American securities—municipal bonds, industrial stocks and bonds, etc.—sold in this country by foreign investors can only be estimated, but Mr. Loree puts the total of all American securities sold back to people in the United States by foreign holders in the last year and a half as in excess of $1,500,000,000.

In addition to this, not only the belligerent nations but other nations have come to the United States during the past two years to borrow money on government bonds, and not only on government bonds but on bonds of cities, railways, industrial enterprises, etc. The National City Bank of New York has just published statistics showing the total foreign loans placed in the United States since the beginning of the war to be $1,981,000,000, in round numbers.

The international trade balance then stands about as follows:

American securities sold by foreign holders to Americans	$1,500,000,000
Foreign bonds and stocks bought by Americans	1,981,000,000
Net gold sent to the United States from foreign countries	383,000,000
	$3,864,000,000
Value of U. S. exports over imports for three years ended June 30, 1916	$3,700,000,000

Of course these figures are only approximate, and further they do not show the entire transactions of international trade; the moneys paid for freight to foreign ship owners, money used by travelers, direct remittances between individuals, etc., are not included. These items are all small, however, compared with the vast sums above recorded.

These figures show that the United States, which for so many years was a debtor nation, relying largely on Europe for the capital to develop its resources, is suddenly and very rapidly becoming the great creditor nation of the world. If the further enormous increase in the value of exports over imports which was recorded during July and August continues throughout the present fiscal year, the rest of the world will have to pay the United States for its surplus of exports over imports in the year ending June 30 next, the enormous sum of $4,800,000,000. For obvious reasons gold can be used for only a trifling part of this payment; and there is reason to believe that most of the foreign holdings of American securities likely to be sold back to this country have already been transferred. If this is the case, then the only way by which this vast foreign trade can be maintained will be through the purchase of foreign securities by United States investors.

It may seem at first sight that so enormous an amount of capital invested abroad would make a scarcity for those who seek to raise money here for home enterprises. The indications are, however, that the amazing prosperity which the United States is enjoying will permit this diversion of capital and still leave sufficient for home demands. The figures above quoted show indeed that in the past two years United States investors have sent nearly 3½ billion dollars abroad, and during that time interest rates here on standard securities such as municipal bonds have dropped to a lower rate than prevailed before the war.

That higher interest rates are likely to prevail here, however, as they already prevail in all the rest of the world, is the general opinion of economists. Vast indeed are the accumulations of capital available for investment in times when a single great corporation can earn profits at the rate of $257,000,000 per annum, as did the United States Steel Corporation in the quarter ended Oct. 1. There is, however, a limit somewhere, and with all the rest of the world coming to the United States to borrow money and with the demand for money for great works of improvement from cities, railways and industrial and utility corporations at home, the law of supply and demand seems certain to raise the rate of interest; and it may even raise it to levels unknown to the present generation.

Must the Brush Mattress Go?

The brush mattress is a classic on the Mississippi. It has been the symbol, as it were, of the river-protection work there, the one necessity handed down to successive engineering generations. While varying in detail in different localities and experiencing at least one very decided change in design, it has been for a half century practically the only way the river engineer could hope to hold the unstable submerged banks from caving under the drive and cut of a flood-water current.

In spite of this evidently successful career, engineers are now casting about for some substitute for the willow mattress. This does not mean that the mattress has at last proved unsuccessful, although to be sure, it has not a 100% stability under adverse conditions, but that willows are getting scarcer in the Mississippi Valley, and therefore harder to procure and more expensive to place and that labor in the Mississippi Valley is becoming expensive. On the river as elsewhere in the South, negro laborers are not so plentiful as they once were, and those that are available cost more. It takes a seemingly disproportionate number of men to build one willow mattress, and where men are hard to get or when their wages are very high, the difficulties of weaving measurably increase.

The principal substitute thus far tried for the willow mattress has naturally been concrete, the modern cure-all for all structural ills. The possibility of carpeting a sloping under-water bank with a neat, flexible mat of permanent unbreakable material has appealed to a number of engineers. On the Mississippi it has been particularly appealing, because there is available a great quantity of river gravel which can be dredged right from the river and used in its natural gradation. So used it does not make a concrete of maximum strength, but it is one of sufficient strength for the purpose at hand.

The first application of the concrete idea was the use of small blocks, wired together both laterally and horizontally to form an entirely flexible mat. Such a design was most successfully used on the Ishikari River in Japan, and has been described a number of times in *Engineering News* by the chief engineer of the district there. It also has been experimentally tried on the Mississippi, and in a greatly improved form is about to be installed in the third district of the Mississippi River Commission's work.

The second method of using concrete for this work is to cast on a barge a solid reinforced-concrete mat, which, when set, is let over the side of the barge to pave the under-water bank. In this issue of *Engineering News* there is described a successful application of the concrete slab scheme, so successful at least in a full-sized experimental plant, that the Mississippi River Commission has appropriated $75,000 for actual work on the first and second districts of the river.

Few realize to what depth and what current the Mississippi River bends are subjected. To let down slowly a large plane, such as a concrete mat presents, in a current of 9 miles an hour and a depth of 100 ft., is to fly in the face of Providence. It would be practically impossible to hold either the slab or the barge from which it depends. To avoid the danger of such a contingency, Major Markham in his new scheme has suspended his entire slab only a few feet below water surface, where it will get the minimum effect of the force of the current. Once balanced there, the whole slab is let go at once, by an ingenious series of triggers controlled from one point. Held at its upper end to the bank and controlled by lines to the barges, this slab drops through the water very quickly and reaches its resting place before it can be warped or twisted.

The device has all the advantages of concrete for mattress work; that is, it uses the local material (except cement) and it can be operated by comparatively few men. The main expense is in its first cost, so that the total cost of laying the mattress should decrease in time, along with the amount of mats laid. At the same time, the heavy flexible mat which should easily accommodate itself to the movement of the bank would certainly seem to protect that bank much better than the brush mattress, which, while entirely flexible, is still subject to breaks due to large caves, and to the loss of its superimposed riprap.

Why It Is Economy To Study Foundation Conditions

In this issue there is described the extensive cracking and settlement which has occurred to the works just completed by the City of Cleveland for the filtration of its public water-supply. As described in that article, the movement has been so serious that it has been necessary to take down part of one of the main buildings to save it from falling down and wrecking the structures which it incloses. Elsewhere the cracks are so extensive that some of the tanks which have been built will not hold water. The most serious aspect of the situation is that the earth subsidence is still continuing and in some places apparently at an accelerated pace. Nobody knows at present whether this movement of the underlying earth will go on until the entire plant is destroyed or whether a condition of equilibrium will be reached soon enough so that the damaged structures may be repaired.

As to the cause of the earth movement, those responsible appear to be a good deal in the dark. There is, however, enough information to make it clear that in the earth strata, 100 ft. or more in depth, which lie between the filter-plant foundation and bed rock, there is a considerable amount of shifting and unstable material. This is in fact what might be expected in view of the general location on which the filter plant is built.

The occurrence is a new illustration of the wisdom of thorough preliminary investigation as to foundation conditions before building an important structure. Most engineers are only too well aware, however, that very often it is difficult or impossible to make those who hold the purse strings, especially public officials, realize the importance of such thorough engineering investigations prior to undertaking actual construction.

It may frankly be admitted, too, that there are cases in which it may be better to run a certain amount of risk than to spend a large amount of money on investigating foundation conditions when the result of the investigation may after all be inconclusive. Of course, where an engineer builds a structure which will produce concentrating loading, such as a bridge pier or a dam, he can and frequently does make thorough investigations as to what the underlying material is on which his structure is to rest. The cases are only too numerous, however, in which this is not done and in which failure occurs as a result.

Some of the older readers of *Engineering News* may recall, as a typical example, the case of the South St. bridge in Philadelphia, a stone arch structure built in the '70's with piers founded on piles that had been driven to what was apparently a solid foundation of boulders embedded in hardpan. Some time after the completion of the bridge, one of the piers began to settle, and the movement continued and increased until the pier broke through the stratum of boulder hardpan and sank into a layer of soft mud which underlay this stratum, causing the total collapse of the bridge.

It would have been a simple matter to have determined by borings the character of material under the pier foundation; but it is far from a simple matter to determine the character of the deep earth strata underlying an extensive area, such as that covered by the Cleveland filter works.

Some pertinent suggestions in this connection were made in the presidential address of Sir Maurice Fitzmaurice, President of the Institution of Civil Engineers, delivered on Nov. 7:

> I do not suppose there are any engineers in this room who have carried out undertakings to any extent who have not had at some time or other to lament failure or accident in connection with at least some part of their work. . . . Of the principal matters which cause trouble, the first one in my opinion is the small knowledge we are able to obtain of the conditions which exist below the surface of the earth on which everything has to be founded. It is commonplace to remark that the information obtained from borings is not always reliable, particularly when the ground is of a variable character. All we obtain from borings is a rough idea of the nature of the ground in the exact spot where the boring has been made.

Turning to the situation at Cleveland, it is quite possible that if a series of borings had been made over the site of the filter works, supplemented probably by the sinking of some test pits, enough might have been learned regarding the unstable strata underlying the site to put the engineers on their guard as regards the location or the design of the structures they were to build.

On the other hand it must be remembered that the foundation pressures involved in the Cleveland filter-works structures were extremely low. Even with complete knowledge of the underground conditions it is likely that no engineer would have been wise enough to predict with certainty that any troublesome movement would occur under these structures, spreading over such a large area and with such small concentrated loadings.

Letters to the Editor

Computing the Hydraulic Jump

Sir—Your issue of Sept. 21 contains a very interesting article by A. C. Norton on the "Hydraulic Principles of Flume Intakes and Outlets." In regard to intakes attention is wisely called to the common error of "making no allowance for velocity head"—that is, the error of neglecting to provide for the creation as well as for the maintenance of velocity. In regard to outlets the question of how much of the velocity head can be regained is a difficult one.

Two different and distinct conditions of flow are recognized. First, the ordinary case when the velocity in the flume is less than $\sqrt{g \times \text{depth}}$. This is always the case unless the flow has been throttled at the entrance or at some other point upstream. It is a sort of condition of stable equilibrium. The water is flowing at the "upper alternative stage." The article in question states that, though theoretically possible, it is practically impossible to regain any of this velocity head.

It may be unsafe to depend on regaining any, but it appears to be good practice to flare the exit of a flume or conduit slightly, thereby tending to slow up the velocity gradually and thus regain a portion of the difference in velocity heads before and after exit. This means the water level in the flume may be slightly lower than below the flume. There is such a thing as an "open venturi." [1]

The second condition of flow, entirely distinct from the previous one, is when the velocity is greater than $\sqrt{g \times \text{depth}}$. The water is flowing at the "lower alternative stage." It is in a runaway condition, which is stopped by the "hydraulic jump," the height of which represents velocity head regained. The principles involved in this jump have been thoroughly discussed in the *Proceedings* of the American Society of Civil Engineers, concluding with the writer's closure on p. 291 of the February, 1916, *Proceedings*.

Confining our attention to rectangular channels, if we let d and D = the depth before and after the jump respectively, and v = the velocity before the jump, then the two variables $J = \frac{D}{d}$ and $S = \frac{v}{\sqrt{gd}}$ will be found very convenient in practice and greatly simplify all the formulas involved in the case. The entire matter is summarized in the diagram of Fig. 35 on p. 292 of the February *Proceedings*. The formula for the jump given by Mr. Norton reduces to $J^2 = 2S^2$. To show that this is in error, it is only necessary to take a case when $\frac{v}{\sqrt{gd}} = 1$, the critical stage when no jump could occur. Substituting $S = 1$ in the formula $J^2 = 2S^2$, we find $J = \sqrt{2}$, corresponding to a jump of about four-tenths the depth of water in the flume.

[1] See "Engineering News," Aug. 10, 1916, p. 270, for description of a venturi flume.

It appears that the correct equation for the height of the hydraulic jump in a smooth rectangular flume, when simplified in terms of the above variables, is $J^2 + J = 2S^2$. This is the formula of Professor Unwin, deduced by equating moments before and after the jump. R. D. Johnson has shown that this formula is thoroughly consistent in its derivation with an energy equation between velocity and pressure heads before and after the jump. The writer's diagram in Fig. 35, referred to above, shows that this equation is verified by the recent noteworthy experiments of Prof. Arnold H. Gibson.

Mr. Norton states that it is better to count on only about half the theoretic height of jump. It would undoubtedly be a safe precaution to do so in practice. However, it is well to note that the diagram shows that the experiments which have been performed, under ideal smooth-flume conditions, give a jump just as high as that computed by the theoretical formula $J^2 + J = 2S^2$. This is apparently because this formula considers the internal friction losses and accounts for everything except such relatively insignificant friction as that of the sides and bottom of the flume.

The term "theoretic height" might better be applied to the equation $2J^2 - S^2J = S^2$, which gives a greater height of jump—in fact, gives the maximum height theoretically attainable if the jump could be assisted by a smooth obstruction in the bottom of the flume, which would prevent eddy losses. In this connection it might well be stated that there are of course certain problems, such as the prevention of scour, in which the factor of safety lies in using a higher instead of a lower height of jump than given by the Unwin formula.

Although the use of the above variables J and S greatly simplifies this formula for the jump, nevertheless it is a quadratic equation; and it so happens that a truly simple equation can be substituted for it without sacrificing any accuracy that is worth while in hydraulic computations of this sort. The equation is:

$$D = \frac{v\sqrt{d}}{4} - 0.45d$$

Apparently this gives the resulting depth D practically attainable by the hydraulic jump in a perfectly smooth channel of rectangular cross-section in which water is flowing with depth d and velocity v. The results agree, within about 1%, with those of the theoretic quadratic Unwin formula, throughout the entire range of practical use. Further reference may be had to p. 1110 of the August, 1916, *Proceedings* of the American Society of Civil Engineers.

KARL R. KENNISON.

Providence, R. I., Sept. 25.

[A proof of the above letter was submitted to A. C. Norton and his reply follows.—Editor.]

Sir—There are several reasons for not recommending a general practice of using the head that can be gained at the outlet of flumes which carry water at higher velocities than the canal above and below. There is no question but that it is possible to regain part of the velocity

head at the intake, even on velocities lower than the critical velocity required to produce the jump (which is greater than $\sqrt{g \times \text{depth}}$. However the amount of head that can be regained depends on several things.

The amount of head that can be regained for velocities both below and above that required to produce jump depends to a certain extent on the shape of the outlet. In case the outlet is on a curve, or at an angle with the flume as is necessary in a majority of cases in order to connect the flume with the canal, the amount of head that can be regained is entirely an unknown quantity.

The freeboard in metal flumes is usually very small—but a few inches when the flume is carrying full capacity—and an additional factor of safety against overflowing is added by not using the head that may be regained. There is also the question of expense to be considered, as it is much more costly to install an outlet that may be used to regain head as it must be much longer than the ordinary in order to operate properly.

The type of outlet shown in the article on "Hydraulic Principles of Flume Intakes and Outlets" is designed to check the water as little as possible, hence the amount of head that could be regained would be small. If it is necessary to regain as much head as possible the outlet should be designed similar in shape to the intake. In case the velocity is high enough to produce jump the danger of the jump occurring too close to the end of the flume and overflowing may be prevented by making the concrete outlet the same size and shape as the flume for a few feet, with the walls raised, and then gradually flared out to the shape and size of the canal section, similar to the design shown for the intake.

The formula which Mr. Kennison shows reduced to $J^2 = 2\ S^2$, and in which he points out the error, is the Merriman formula and at the time this article was written, which was before the publication of the discussions in the *Proceedings* of the American Society of Civil Engineers for January, and February, 1916, the Merriman formula derived from Bidone's experiments was practically the only source of information on this subject. As these formulas are derived from experiments in rectangular channels they must necessarily be used with caution when applied to semicircular flumes.

Denver, Colo., Oct. 7, 1916. A. C. NORTON.

Design of Flume Outlets

Sir—The design of flume outlets as outlined by A. C. Norton in the *Engineering News* for Sept. 21, under the title of "Hydraulic Principles of Flume Intakes and Outlets," appears to the writer not to be in accordance with the best practice. Equation (2) is equivalent to a statement that velocity head can be recovered at a flume outlet only where the hydraulic jump occurs. Abundant experimental data exist proving that this is not the fact, but that the percentage of head recoverable is much greater when the flume velocity is lower than that which will result in a jump, the necessary losses involved in the jump being avoided. Also, equations (2), (3) and (4) apply only to rectangular sections where the jump occurs *within the flume*, and are not applicable to semicircular sections, as evidently intended by the author, nor to cases where the hydraulic jump occurs in the transition, unless, of course, the transition has a rectangular cross-section. In the latter case v would refer to the velocity at the point where the jump occurs, and not to the velocity in the flume as stated. It is important to know whether the velocity at any point exceeds the minimum velocity at which the hydraulic jump may occur in order that the increased losses due to the jump may be allowed for and that precautions may be taken to prevent the jump from occurring in the flume just above the outlet structure. The simple formula given by Mr. Norton may be used in the case of a rectangular flume, but the corresponding formula for a circular or special section is complicated, and it is usually best to use the general formula *for the critical velocity head,*

$$hv = \frac{A}{2T}$$

where

hv = Velocity head for *critical* velocity;
A = Area of cross-section;
T = Width of section at top of water.

This equation, which applies to any form of section, provided only that A and T are *continuous* functions of the depth has not, so far as the writer knows, been published and a demonstration may be of interest. An extensive discussion of the hydraulic jump appeared in a series of articles in the *Proceedings* of the American Society of Civil Engineers, January and February, 1916. In these articles it is clearly brought out that a given quantity of water flowing under a given "total head" in a given channel may flow at either of two alternative depths, and that the hydraulic jump occurs when the depth changes from the lower to the higher stage. There is always one depth at which the two stages coincide, the total head being a minimum, and the jump cannot occur unless the depth is less than this critical depth. Let

D = Depth of water in any channel;
hv = Velocity head;
H = Total head = Dhv;
Q = Discharge;
V = Velocity;
g = Acceleration of gravity;
T = Width of section at top of water;
A = Area of section = some function, $f(D)$, of the depth.

Then by definition,

$$\begin{aligned} H &= Dhv \\ &= D\frac{V^2}{2g} \\ &= D + \frac{1}{A^2} \times \frac{Q^2}{2g} \\ &= D + \frac{1}{f^2(D)} \quad \frac{Q^2}{2g} \end{aligned}$$

Differentiating,

$$\frac{dH}{dD} = 1 - \frac{f'(D)}{f^3(D)} \times \frac{Q^2}{g}$$

where $f^3(D) = A^3$ and $f'(D) =$ (the first derivative of A with respect to D) $=$ the top width T; and H is a minimum when $\frac{dH}{dD}$ is zero, or when $\frac{A^3}{T} = \frac{Q^2}{g}$. Since $Q = AV$ this reduces to $\frac{A}{2T} = \frac{V^2}{2g} = hv$, the equation given above.

For a rectangular section, since $\frac{A}{2T} = \frac{bD}{2b} = \frac{D}{2}$, we

may write $\frac{D}{2} = \frac{V^2}{2g}$ or $v = \sqrt{gD}$, which agrees with Mr. Norton's equation (2). It is also interesting to note that $\frac{D}{2}$ is equal to hv at the critical depth for a rectangular section. The situation is illustrated graphically herewith in Fig. 1. The curve is plotted for 150 sec.-ft. flowing in the section shown. If the flow is taking place under a total head of 5 ft., the depth may be either 1.4 or 4.9 ft., and if in the case of low stage flow, with depth equal to 1.4 ft., the flow in the lower part of the channel be retarded by a change of grade or otherwise, the water surface may be made to jump, theoretically, to a depth of 4.9 ft. The actual height of jump (for rectangular channels), which is less than the theoretical, is discussed in the *Proceedings* referred to above and will not be taken up here. If the depth is equal to or greater than the depth at G, no jump can occur, hence the critical depth is found where H is a minimum.

It should be noted that e in Mr. Norton's equation (3) is equivalent to C in the well-known formula $v = C\sqrt{rs}$, r being assumed $= D$; e should not be taken as a constant, but should be identical with the value of C used in determining the velocity in the flume. Unless the channel is very wide this formula should read $s > \frac{gD}{rC^2}$. Mr. Norton's equation (4) is equivalent to the Merriman formula for the height of jump in a rectangular section, and the relation of this formula to the Unwin formula and to the theoretical height of jump is illustrated graphically on page 292 of the *Proceedings* for February, 1916. So far as the writer is aware, no formula has been devised for the actual height of jump in other than rectangular sections.

The outlet structures shown in Mr. Norton's article are more suited to the destruction than to the conservation of the kinetic energy in the water and should not be used where the recovery of head is important. A better form of outlet would be Mr. Norton's intake reversed, though the outlet should be longer than the intake in a properly proportioned installation. Obviously, since eddies destroy energy, the outlet should be made as smooth and as gradual as possible, and the velocity should be reduced from the flume velocity to the velocity in the canal with a minimum of shock. In the structure shown by his "Type III," the depth, and consequently the critical velocity, in the outlet is greater than in the flume, while the actual velocity is higher in the flume; hence, if there is a jump it is likely to occur in the flume rather than in the transition as shown. If the flume velocity exceeds the critical velocity, there should be a hump in the floor of the outlet rather than a depression. It is claimed that by using the proper form of submerged weir the hydraulic jump may be made to take place with very little loss.

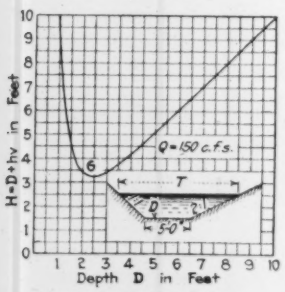


FIG. 1. DEPTH-HEAD RELATIONS

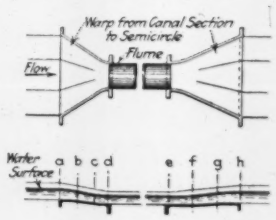


FIG. 2. INTAKE AND OUTLET FLUME

Where there is no hydraulic jump, or where the jump is made over a suitable weir, the writer suggests the following formula to be used for both intake and outlet:

$$h = K\frac{V_1^2 - V_2^2}{2g}$$

h = Change in elevation of water surface in feet;
V_1 = Velocity in flume;
V_2 = Velocity in canal;
g = Acceleration of gravity;
K = An experimental coefficient to be determined separately for intake and outlet.

The values of this coefficient vary with the design of structure, the range in practice probably being from about 1.6 to 1.1 for intakes and from zero to 0.7 for outlets. For careful design $K = 1.2$ at the intake and $K = 0.6$ or 0.7 at the outlet is believed to be conservative. This formula is identical with Mr. Norton's equation (1) except that $K = 1$.

In order to make the regain of head possible it is, of course, necessary for the water surface in the flume to be lower than in the canal. The type of intake and outlet shown herewith in Fig. 2 is believed to conform to good practice for ordinary purposes. Where it is important to keep losses down to a minimum any number of sections a, b, c, d and e, f, g, h may be taken and the formula $h = K\frac{V_1^2 - V_2^2}{2g}$ applied between each two sections, h being the change in water surface elevation between sections, V_1 and V_2 velocities at the sections and K the proper coefficient. The structures can then be adjusted to make the water surface follow a smooth reversed curve as shown. If the conservation of head is of little importance, the structures may be simplified. It should be remembered, however, that if a large part of the kinetic energy of the flowing water is converted into static head it will not create eddies and cause erosion in the canal below, and the amount of protection necessary to prevent erosion will be correspondingly reduced.

JULIAN HINDS,
Assistant Engineer, U. S. R. S.

Denver, Colo., Oct. 6, 1916.

Lawyers Select the Juries

Sir—In the article by R. Fleming, *Engineering News*, Nov. 23, p. 967, on "The Engineer as a Juror," the inference is drawn that the low standard of jurors is due to the effort of intelligent men to be excused.

My brief experience on the petty jury in a civil court makes me believe that the low standard is due solely to the efforts of the lawyers, who promptly excuse the "electrical engineer," "telephone engineer," "civil engineer" and another man, "the most intelligent-looking in the box."

In my case I knew I would have to report to the court twice a day for two weeks, whether on the jury or not, so I always gave my business as "draftsman" and was accepted as being not too bright to please the lawyers.

I do not believe juries will be much improved until the judge is given more discretion and the lawyers given less in selecting them. ALLAN F. OWEN.

Chicago, Ill., Nov. 26, 1916.

Serious Settlement Destroys Part of New Filter Plant

SYNOPSIS—The water-filtration plant of Cleveland, which is just completed, has settled at some points 6 in. to 1 ft. A portion of the filter building has been so badly injured that it is being demolished. The subsidence started during the construction, in 1914. No explanation of the trouble has been found, and measures for safeguarding the plant have not been devised. The following descriptive account has been prepared in the absence of full data, withheld by the city officials.

The new Division St. plant for filtering the water-supply of Cleveland, Ohio, not yet put into service, has been seriously damaged by extensive cracking, caused by subsidence of the underlying earth. Conditions are growing worse. At the west end of the 125x730-ft. filter house the state of affairs is so bad that a 40-ft. length of the house is being taken down to forestall its collapse. While the subsidence is worst at this point, it extends through the whole length and width of the filter building and into the coagulation basins adjoining to the south.

Part of the trouble is two years old; part is very recent. The first difficulties developed at an early stage of construction. The substructure for the filter house was completed late in 1914, and about that time the footing slab under the building and the filters, a continuous reinforced slab 14 in. thick, was seen to be at least 5 or 6 in. low at its ends, though it had been laid level.

At the same time or even earlier the north filter boxes, resting on the side portions of the slab, cracked away from the central floor—the operating gallery. The longitudinal crack was carefully patched up at that time. As evidenced by small insert pieces placed at special points

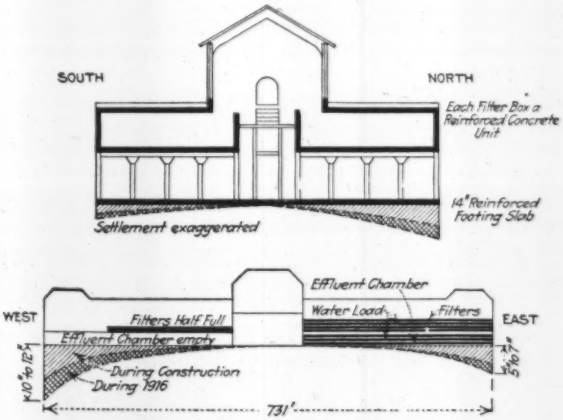


FIG. 1. DIAGRAM SHOWING SETTLEMENT UNDER THE FILTER HOUSE

and still in place, the crack had opened up 1½ in. The trouble was diagnosed as settlement along the northerly edge of the filters, and to strengthen this edge a very large amount of grouting was done through pipes put down through the footing slab. Some 5,000 bbl. of cement was used in this work, which was paid for as an extra.

At this period, also, the settlement of the west end was sufficient to pull some of the ceiling girders under the filter boxes away from their columns. Several heavy brick piers were built under these girders.

The superstructure of the filter house was completed (a separate contract) in 1915. The subsidence continued, or perhaps new movements developed, while the wall brickwork was being laid.

Because of prospective litigation over the failure and future rebuilding of the clearwater basin of the plant, 500 ft. to the west of the filter house, the city authorities refuse information bearing on the present and past movements. It is conceded, however, that the subsidence has been going on continuously during the entire season of 1916 and still continues.

A system of accurate leveling was instituted in April, 1916, to keep track of the movement. Shortly afterward,

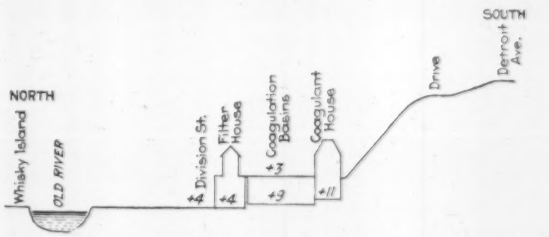


FIG. 2. CROSS-SECTION THROUGH FILTRATION PLANT

water was put into some of the filters, part of the effluent chambers underneath and some of the coagulation basins. This water load was applied gradually.

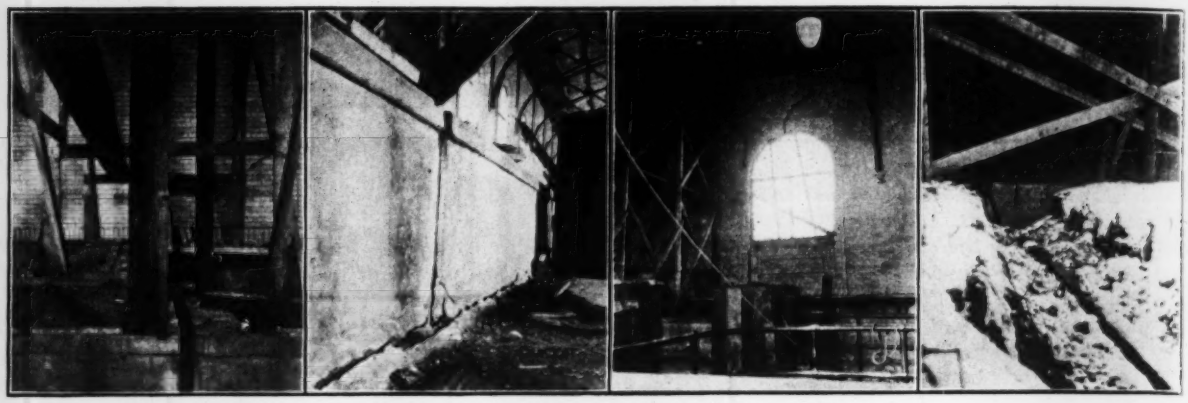
Indications are that the movement has been greater during the past two or three months than in the first half of the year. During the period from April to October the filter house went down 2 to 4 in. at its extreme ends, the greater amount at the west end.

Filter House Settles at Ends and Sides

The peculiar distribution of settlement in the filter house is possibly significant. Transversely, the north and south edges of the filters have gone down, leaving the bottom slab highest at the center. This is perhaps a natural occurrence in view of the excess load on the side portions, due to filter boxes and superstructure, and the continuity of the foundation slab. However, longitudinally the same concentration of settlement in the end portions appears in even more marked degree.

The sketch, Fig. 1, represents very roughly the distribution of the settlement of 1916, added to the earlier subsidence. The sketch is based on the best data obtainable outside of the city's records. The administration building, at midlength, is practically undisturbed. Thence east and west there is progressively increasing subsidence, going sharply to a maximum in the length of the last two filter bays.

The opening between the last two filter boxes at the west end is the most prominent gap, being 2½ in. wide in the north row and 1½ in. wide in the south row. This



FIGS. 3 TO 6. CRACKS SHOWING IN FILTER HOUSE AT CLEVELAND FILTRATION PLANT

crack has torn the walls of the house apart, and the settlement that causes the crack also is dropping the lower walls away from the brickwork.

There are plenty of other cracks throughout the filter house. The operating-gallery floor slab is pulled apart at numerous transverse cracks, and the passageway slab below it similarly. The columns under these slabs are split, in some cases, by the east-west pull. The administration building (at midlength of the filter house) is also showing cracks. Its walls also show slight settlements independent of the movements of the filter-house.

Coagulation Basins Cracking Along Edges

Damage is by no means confined to the filter house, but extends into nearly all parts of the plant. The north side of the coagulation basins, where a narrow two-story operating gallery extends along the 850-ft. length, shows a general arching in east-west direction similar to that of the filter house. Many transverse cracks, running north-south in the middle part of the length and elsewhere usually northeast-southwest, prove this arching and its damaging effect. A direct measure of the movement is found in the fact that both ends of the gallery are about 6 in. below the middle, though originally they were about 1 in. higher than the middle.

The coagulation basins, though integral with the north operating gallery, do not show by cracks that they participated in the excessive subsidence of the east and west ends. Specific measurements are not available.

The west basin is badly cracked and will not hold water. The other five basins are full. The principal cracks in the west basin are two north-south roof cracks, one running the length of the barrel vault along the west, and the other along the crown of the second arch span east of here. At both the roof is open 1 to 2 in. The middle 150 ft. of the west wall is tipped outward slightly and has cracked away from the adjoining sections of wall. Other roof cracks occur.

Cracking of minor amount is found in the south operating gallery and in the mixing chambers. The coagulant house is apparently not disturbed.

Bad Soil Conditions; Little Definite Knowledge

The filter plant lies at the foot of the lakeside bluff near West 45th St. and occupies a flat stretching 600 ft. north of the Old River—the former mouth of the Cuyahoga—beyond which lies the ¼-mi. width of Whisky Island (Fig. 2). The site was 10 to 30 ft. above lake level; but as the excavation was in old fill and the bluff back of it has a fill face, the filter site was probably lower originally and may have been marshy.

Some of the original exploration borings showed peat, and the view has recently been entertained that a bed of peat underlies the site. This opinion is conceded to be largely presumptive.

While the boring record is not available, it is known that uncertain clay and sand strata were found. Rock is 100 to 130 ft. below lake level. Wet quicksand exists at an elevation equal to or above the river bottom.

Slips of the hillside were a frequent source of trouble during construction, in one case burying a steam shovel. Their nature was not that of a simple slide; vertical subsidence occurred, accompanied by squeezing out of unstable clay-sand masses at the foot of the bluff. To what extent these troubles involved old fill and to what extent original soil was not determined.

At the clearwater-basin site, 500 to 1,500 ft. west of the filter plant, the lateral movement was more pronounced. Here the footings for the southerly wall of the basin, which were poured in separate blocks, frequently shifted northward—that is, away from the hill—over night. Movements of these footing blocks exceeding 1 ft. occurred, and some heaving occasionally accompanied them. The hill slope was in all cases held well back of the footing excavations, and the movements were due to northward flow or squeezing of the underlying soil. The footing depth here was nearly 10 ft. below lake level—the clearwater basin has its floor well below datum and thus is like a dry-dock excavation.

As bearing further on the soil conditions, it is worth notice that the heavy pumping station, lying between the filter house and the clearwater basin, but resting on a substantial pile foundation, has shown little or no settlement. The piles here go down to depths of 40 to 45 ft. below lake level. Evidently, they pass through the unstable strata and are well seated in firmer ground.

Trenching Near Filter Caused Soil Movements

West and northwest of the filter house and 100 ft. or less distant, a 72-in. steel main was laid in 1915 with its bottom 12 to 15 ft. below ground, or at El. -9. The trench was unsheeted. Its bottom rose very decidedly before the pipe was laid. The pipe, resting directly on the soil, has settled or risen in places since completion of the main, indicating that the instability of the soil was not wholly neutralized when the trench was filled.

Two other sets of trenches were dug somewhat later, near the west end of the filter house. One of these was a pair of sheeted trenches leading out from the end of the filter building and 15 ft. below the level of its bottom slab. These trenches were for the cast-iron effluent pipes from the filters, connecting some distance out with a reinforced-concrete conduit to the clearwater basin. No disturbance was noticed that could be charged to their construction.

However, two deep supply-tunnel trenches put down 150 ft. to the north, a little later, made very considerable trouble. These trenches were inside of tight steel sheeting, well braced. When excavation was down nearly to their 30-ft. depth, the bottom rose somewhat, and the trenches moved bodily northward, sheeting, bracing and all, 12 to 18 in. This caused immediate settlement and opening of cracks at the west end of the filter house.

Plant Designed for Very Low Soil Loadings

It is said that the footing loads under the filter plant range from 1,500 lb. to 3,000 lb. per sq.ft. Under the filter house the dead-load averages 1,500 lb., and the total load 2,700 lb. The coagulation basins have a general floor load, from floor, water and roof, of between 1,800 and 2,300 lb. per sq.ft. The outer walls may have an extreme edge pressure of about 3,000 lb. per sq.ft.

These very low loadings are applied to a soil of miscellaneous fill. This soil was tested by loading-platforms in 1914, and the conclusion was reached that 3,000 lb. per sq.ft. would be safe. Some thought was given to driving concrete piles under all or part of the plant, but the idea was rejected.

The filter house, as already noted, was built on a continuous 14-in. concrete slab, reinforced in all directions. Above the slab, however, the building is cut apart by frequent expansion and construction joints and has no continuous reinforcement.

The coagulation basins rest on a plain-concrete groined-arch floor concreted in alternate diamonds, as is commonly done. As an afterthought, 10-ft. squares of reinforcement were put under the columns. The mixing chambers are reinforced work practically throughout.

The Situation in Brief

The filter plant presents the picture of a remarkably extensive foundation failure. The actions are most serious at the north and west edges, with maximum movement at the northwest corner of the filter house.

The filter house is arched up at the middle from subsidence of the ends that began two years ago, while the substructure was being built and the average footing load probably did not exceed 1,700 lb. per sq.ft. Later on, subsidences occurred in marked degree when lateral flow of the subsoil was induced by deep open trenches nearby. The movement was continued very actively during 1916 under the influence of the added water load. Distinct increase of subsidence at the west end was caused by placing about 20 ft. of fill along this end, during the past season. A maximum rate of subsidence, at the corner, of 1 in. per month was reached.

Peat is known to exist in places and is suspected under the whole area. Direct compression of this peat by the superimposed load is held to blame by some of those who have been consulted.

Compression (vertical squeezing) and flow (lateral squeezing) of the subsoil are the two chief possibilities. Compression is indicated clearly at the west wall of the coagulation basin, which tipped outward slightly before the adjoining fill was placed. A few of the other occurrences also point to vertical compression.

Lateral flow is indicated by many of the other phenomena and most distinctly by the northward movement of the deep supply-tunnel trenches a year ago. It is probably the predominant element of the trouble, with vertical compression as an auxiliary and complicating factor.

The existence of springs in the bluff and the fact that much water flows through the underdrains under the plant may mean some complication of the conditions by moving groundwater.

Hillside pressure is probably not a factor now at the filter plant, but it is active at the nearby clearwater basin. This structure, which has not been included in the above descriptive statements, has developed in many of its 30-ft. columns cracks that represent a northward bending at the top. Cracks are seen on many of the columns, the south face near the base and on the north face near the top.

That the soil actions are of complex nature also at the clearwater basin is shown by recent outward tipping of the north wall of the basin, and (probably in consequence of this) the development of a few diagonal and longitudinal cracks in the roof.

In the case of the filter house the continuity of the bottom slab and the unequal transverse distribution of load upon it is possibly concerned in the transverse arching. It cannot be more than secondary to the subsoil movement, however.

Relation of the Filter Plant to the Water-Supply

The construction work on the filter plant was practically completed by the end of last February. The delay in putting it in operation is a serious matter for the city. According to a review of the Cleveland water system by C. F. Schulz before the Cleveland Society of Engineers the plan of development was to complete the Division St. filter plant and the new west side tunnel, put them in operation for the supply of the entire city, and then shut down the pumping plant on the east side of the city, unwater the lake tunnel which supplies it and make examination and necessary repairs, since the tunnel is believed to be in unsafe condition. Haste is imperative so that the work may be completed and the east side tunnel restored to service before the growth in water consumption reaches a point beyond the capacity of the west side tunnel and filter plant supply.

What the City Is Doing About It

As stated in a description of the new filter plant in *Engineering News* of Oct. 19, 1916, "the plant is being tuned up under the direction of J. W. Elms." The "tuning up" may be described as follows:

1. The westerly 50-ft. length of the filter-house superstructure is being taken down, for fear it may collapse. A low wooden shed will be built to protect the control boards, etc. The westerly filter boxes (one each along north and south edge) will remain out of use. The parts of the effluent chambers below them are also unserviceable; but as the downtakes to the effluent pipes are at the extreme west end, provision is being made to carry the water to them. This consists in building a new reinforced-concrete end wall across the effluent chambers,

50 ft. from the west end, and constructing a closed timber flume from openings in this new wall to a connection with the downtakes. At the same time several brick piers are being built in the effluent chambers near the west end to hold up the ceiling girders where they are tearing away from their column seats. The westerly unit of the coagulation basin is empty and may be abandoned.

2. The other five coagulation basins have been filled with water, and most of the filters have been filled. This water load was applied gradually, beginning in the spring of 1916, with a view to bringing on the subsidence in easy stages and ultimately arriving at a condition of stability.

The clear water basin is to be rebuilt at once, as reported in *Engineering News* of Nov. 23, 1916. Its condition is largely or wholly due to defective concrete, which caused a section of roof to fall on July 10, 1916, as reported in *Engineering News* of July 20 and 27, 1916.

No active consideration has been given to methods of underpinning or otherwise supporting the filter-plant structures against continued subsidence. Such advice as has been obtained by the city officials is to the effect that probably the worst subsidence actions are now over and that keeping the plant loaded ought to develop final stability by next spring.

There is no evidence, however, that the movements have been decreasing recently. On the contrary, new cracks developing from time to time point toward continued movement.

What the Established Engineer Owes the Beginner*

By Isham Randolph†

What I wish to speak of more particularly is the helpfulness that should be extended by the older to the younger, the experienced to the inexperienced, the veteran to the recruit. The importance of this is borne in upon me by recollections spanning twoscore years of professional life.

I have attained to a standing in the engineering profession which is a source of satisfaction to me, and why have I attained it? Because of the helpfulness of my seniors. In 1868 I put my hand, not to the plow for I left that in the furrow, but to the ax in a railroad survey party. It was hard work, harder than similar work today, for in the old Valley of Virginia contending armies had burnt up all the fence rails and the axman had to cut down trees, cut them into proper lengths, split into stake sizes, smooth, sharpen and mark them; and this done, he had to make them into bundles and pack them on his back. Those green stakes were heavy, and each stake that was stuck was a welcome lightening of the axman's load. Such an idea as having stakes prepared at a sawmill and distributing them by wagon was in those days considered preposterous. At the close of each day I used to feel that I could not stick it out another day; but a night's rest, pride and the necessity of making a living sufficed to put me back on the job each succeeding day while it lasted.

I came within the helpful influence of James L. Randolph, Chief Engineer of the Baltimore & Ohio R.R. During the thirty years of his incumbency of that office he trained many young men. A young man in any of his engineer corps was a man in whom he felt a personal interest akin to that of a father for his son. We were of his official family in a real sense. He took an interest in our development. He knew us individually, and he used to find out how we were getting along, find out what our technical stumbling blocks were; and he would help us to surmount them by verbal instructions and by written elucidations of our problems. Most of the boys who were of his professional family have followed him into the great unknown, but the few of us who are left cherish a grateful memory of what he did for us.

I have said enough to let you see how much I owe to precept, example and sympathetic aid in those early days of my professional life, when the need was so great, and how that experience, as long as it is remembered, will incline me to doing for others what was done for me.

We must bear in mind that the young men who come to us—from the office boy to the college graduate—are not merely flesh-and-blood tools to be used in our work as so much mechanism, but men like ourselves, whose future we shall help to mold. Their destiny is to be worked out, and whatever we can do to make it a high destiny should be done generously and well.

I do not know whether the ethics of the profession are taught in the schools, but from occasional lapses from the code on the part of graduates of some of our technical colleges, which have come within my personal knowledge, I incline to the belief that little stress is laid upon the moral side of the engineer's training.

We must have those who come under our influence understand that no true success can wait upon departures from a high standard of justice and honor. The old chief whose influence upon my life I have before spoken of used to impress upon us that as engineers we held a judicial relation to employer and contractor and that fairness to each should govern all our decisions. The engineer should be sure he is right, then go ahead; his going ahead, however, should not be rough shod, but determined and effective.

*From an address before the Cleveland Engineering Society, Nov. 21, 1916.

†Consulting Engineer, Chicago, Ill

Extensograph Shows That Bridge Leans to Side

Extensograph measurements of stresses in an old highway bridge in Connecticut, made recently for the State Highway Commissioner by Rudolph Welcker, of Springfield, Mass., revealed the curious fact that the south truss in each span of the bridge carries very much greater stresses than the north truss. A survey of the bridge then showed that the trusses lean to the south, partly by distortion in the sway and top-lateral systems, and partly by bending of the truss posts on account of poor details. The following extract from Mr. Welcker's report on the bridge describes this condition:

> The size, fastening and construction of the lateral connections are inadequate for the height of the structure. Unusual stresses due to horizontal forces were observed in the struts which connect two trusses of the same span. The stresses therein become very high during wind storms and the following effect was observed: First, the channel irons of all the vertical posts are pressed together, thereby causing the lacing bars to buckle. Second, the whole superstructure of both fixed spans has been thrown out of plumb, which action should have been counterbalanced by stresses in sway rods and upper laterals. The upper lateral loop rod pins have been bent inward in several places, giving the rods considerable play.

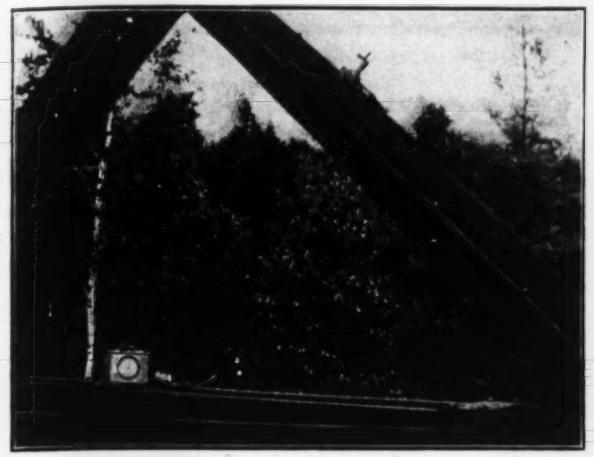


FIG. 1. WELCKER EXTENSOGRAPH ATTACHED

Clock shown drives the tape-winder of the extensograph and of similar instruments placed at other points on the bridge.

The permanent deformation was measured as follows:

East span: North center post 33 ft. high, 3¾ in. out of plumb toward the south, 1½ in. bend in the middle of the post.

South center post: 2½ in. out of plumb, ¾ in. bent.

West fixed span: North center post 6½ in. out of plumb toward the south and ½ in. bent; south center post 4¾ in. out of plumb toward the south, 1¾ in. bent. It is evident that northwest winds have caused this permanent deformation.

The swing span: Southeast main post ¾ in. out of plumb and bent; northeast main post 1 in. out of plumb and bent; northwest main post 3¾ in. out of plumb and bent; southwest main post 1 in. out of plumb and bent.

Investigation was made as to how far the live-load on the bridge floor accounts for these conditions. Secondary stresses were measured in the horizontal struts connecting these posts during the passing of street cars.

The beginning of the failure mentioned above is aggravated by the fact that the vertical posts are entirely without diaphragms and that the sways and upper laterals do not take any stress under ordinary circumstances. The buckling of the lattice bars of the vertical posts has brought a greater strain to bear on the stiff diagonals of the trusses at the assembly of the panel-points, which also begin to show signs of buckling.

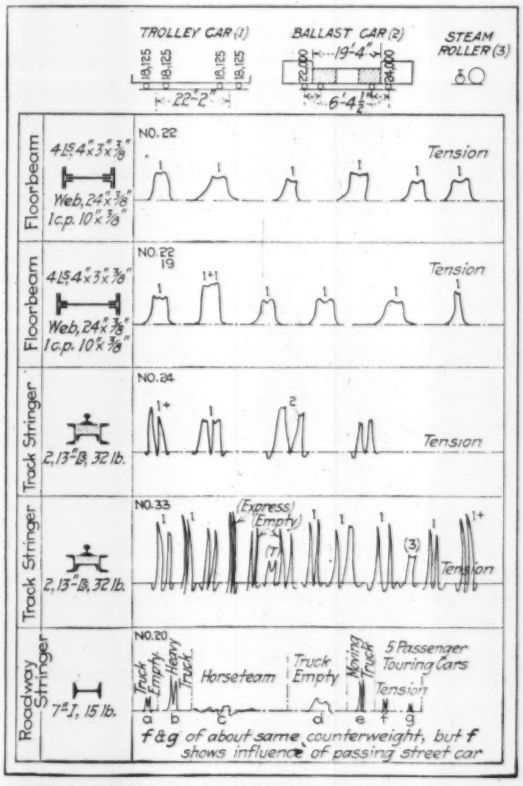
It is considered essential to ascertain from time to time by actual measurement whether any further movement of the trusses is noticeable, and if so, to proceed at once with strengthening of the sway bracing. All hanger rods should be tightened, also the rods forming part of the upper lateral system, and their pins strengthened if required. Stay-bolts should be inserted between the channels of the vertical posts in order to relieve the strain on the buckling lacing.

The bottom angle of the east portal of the east fixed span is rusted through, due to lack of rain holes. These portals should also be inspected from time to time, as they form at present the only means of preventing the failure of the high trusses under high wind pressure.

The bridge crosses the Housatonic River between Milford and Stratford, Conn., and is known as the Washington Bridge. It was built in 1893 and has the light and unsatisfactory construction and detailing of that period. It was reinforced in 1909 and 1913, at some points quite extensively (for example, the entire bottom chord of the swing span and its floor-beams were renewed), and probably by virtue of this work the direct stresses in the main members are not excessive. Bending of the members was found to occur in marked degree.

The two fixed spans of the bridge are each 232 ft. long, with 29 subpanels of 14½ ft., and center depth of 33 ft. The trusses are spaced 19½ ft. on centers. A sidewalk is bracketed out on the north side (although the bridge now leans to the south). The floor-beams are suspended by plate hangers. The bottom laterals are angles, but the top laterals and the sways are rods.

Specimen stress diagrams are reproduced herewith. An interesting point in them is the compression shown in the eyebar diagonal and bottom chord.



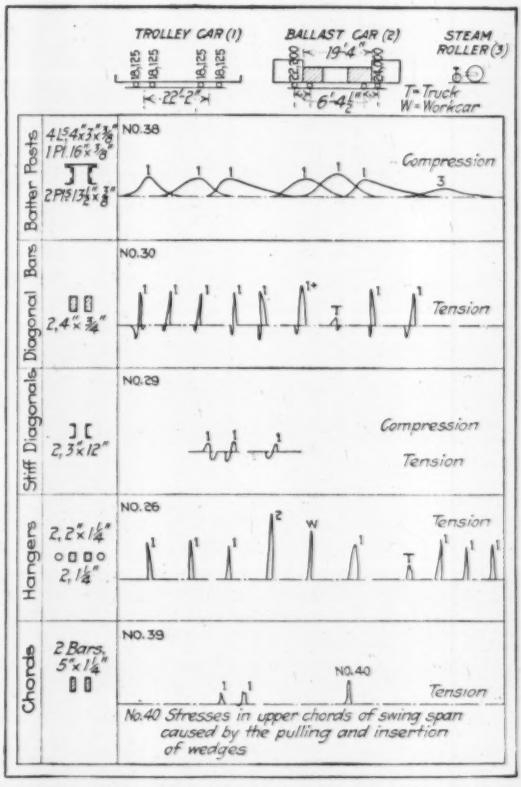


FIG. 2. TYPICAL AUTOGRAPHIC STRESS DIAGRAMS FROM WASHINGTON BRIDGE, STRATFORD, CONN.

News of the Engineering World

Proposed Burial of Garbage at San Francisco

Disposal of San Francisco garbage by burial was proposed on Nov. 20 by the only two bidders who tendered under the city's recent advertisement for disposal in accordance with plans submitted by bidders. The bids were under advisement at the date of the latest reports. Richard Schmidt, 857 Mills Building, San Francisco, offered to take all the garbage collected and delivered to him in the Islais Creek district, and bury it under 12 in. of earth or rock, the contract to run for five years, and the private scavengers to pay him 60c. per ton, of which he would pay 20c. to the city the first year and 25c. the remaining four years of the contract. The "sanitary fills" thus made, the proposal stated, would be "sanitary and without noxious odors and free from insects and vermin and satisfactory" to city and county officials. The second proposal was from A. B. Moffit, L. G. Bonzagni and Fred P. Smith, 105 Montgomery St., San Francisco. Two plans were submitted: (1) Burial within the city under a contract running from 1½ to 20 years, the material to be segregated and graded and then immediately sealed "within an impermeable covering, under the patent rights of Fred P. Smith," the scavengers to pay the bidder at least 60c. per ton and the bidder to pay the city 22½c. per ton, or a lump sum of $35,000 a year, as the city may elect. (2) Transportation by water and subsequent burial in one of three outside counties "in a manner satisfactory to the public health authorities having jurisdiction at said sites," the scavengers to pay as already stated and the bidder to pay the city 13c. per ton or a lump sum of $20,000 a year, as the city may elect, the contract to run 10 yr.

Chicago Transit Commission Makes Report

The Commission appointed Jan 31, 1916, to investigate the passenger transit facilities of Chicago and recommend needed improvements has prepared a report which was made public on Dec. 4. The Commission recommends that all the transit lines of the city, surface lines, elevated roads and the subways to be built, should be placed under one management to be under control of the City Council but with a Board of Supervisors in immediate charge with broad powers as to regulation of service, extension, etc. The new corporation should absorb both of the present surface and elevated companies, which should surrender their franchises. The new corporation should receive a franchise terminable at any time the city sees fit to acquire the property, and the city should have also a majority control of the corporation.

The present surface and elevated lines are carrying about 4,000,000 passengers daily (2,460,000 cash and 1,550,000 transfer) with 157,000 additional on the steam and electric suburban lines. To increase these facilities the Commission recommends a nine-year construction program involving a total outlay of about $100,000,000, beginning in 1917. A rapid-transit subway is to be built under State St. at a cost of $10,350,000 and subways for surface cars under Washington St. and Jackson St., at a cost of about $7,181,000. New rolling stock and extensions to surface lines account for about $19,000,000 expenditure. The entire program calls for the construction of 6 single-track miles of subway, 64.5 single-track miles of elevated lines, the surface lines are to have five miles of single track placed in subways, 111 miles of track is to be rebuilt, and 150 miles of new lines will be built.

Following this nine-year program a still larger program of new construction is advised which with the $100,000,000 above referred to will raise the total outlay to $260,000,000 and the total new construction to 53 miles of rapid-transit subways, 158 miles of elevated lines, and 525 miles of surface car lines. It is estimated that this amount of construction and investment will be sufficient up to the year 1950, on the assumption that 5,000,000 people will at that time reside within the city limits of Chicago, who will be adequately served by the transit lines above outlined.

Under the financial plan recommended, the city would use its present traction fund to build subways which will be owned by the city from the start. Its share in the net receipts of the operating corporation will be applied in such a way as to facilitate eventual acquisition of the entire properties by the city.

Among the first work recommended by the Commission is the four-tracking of the north and south elevated lines so that they may render a fast express service instead of a local service as at present, and additional tracks and extension on the east and west elevated lines.

There is to be a complete system of transfers between surface lines, elevated lines, and subways, and while a 2c. charge for transfers will be necessary at the start, it is expected eventually that free transfers can be given.

Chicago Paving Administration Under Fire

An investigation of Chicago paving methods by Prof. Ira O. Baker of the University of Illinois has resulted in accusations of very lax business administration, if nothing worse. The investigation was conducted for the finance committee of the City Council and with the assistance of the finance committee staff. A newspaper synopsis quotes Professor Baker as follows:

> **Skimping on materials, inadequate and in many cases faulty specifications, inferior materials, poor inspection, absolute disregard of many tests in specifications, poor workmanship, and even payment to city inspectors by contractors for overtime or holiday work, seem to be the rule in paving work done by the board of local improvements.**

Professor Baker estimates that about $400,000 a year is lost to taxpayers through inefficient or corrupt administration of the paving work. Specific instances are:

Shortage of material in concrete bases	**$161,184**
Skimping in use of cement for foundations	**52,430**
Shortage of bitumen in binder	**92,730**
Skimping in the use of asphalt for wea[illegible] surface.	**78,777**

The system of inspection in particular is condemned. The published digest of the report states:

> It seems to be common everyday practice, for inspectors to receive pay for overtime, holidays, and Sundays from the contractor, although they are employed to safeguard the interests of the city against the contractor. Such a practice goes to the root of the integrity of the whole inspection service. This, together with a radical disregard of specifications, cannot help having a demoralizing effect upon both contractors and inspectors. Inspectors are not wholly responsible, however, for poor inspection service because of the lack of proper instruction and because of the lack of requisite technical training.

Professor Baker states that 48 inspectors were placed on the pay rolls because of political influence; their previous occupations included bookkeepers, brakemen, barbers, reporters, etc.

Completion of the Ohio State Topographical Survey

The sixth state in the Union to complete its topographical survey, Ohio, make the list now Massachusetts, Connecticut, Rhode Island, New Jersey, Maryland and Ohio. The Ohio work has been put through very rapidly—about 15 yr. only were required. A complete final report is being issued. The first volume, dealing with the resurvey of the famous Ohio-Michigan boundary, is ready for publication. The resurvey was made in 1915 by S. S. Gannett, of the United States Geological Survey, whose detail account of the work presents an instructive commentary on the retracement of lost lines.

ENGINEERING SCHOOLS

University of Washington

The United States Bureau of Mines has selected the University of Washington campus as the site of a Government mining and metallurgical station for the Pacific Northwest states and Alaska. Congress has voted an appropriation of $25,000 a year for the maintenance of the station, but is expected to increase this amount when development demands it. The station will serve Washington, Oregon, Idaho, Montana and the coastal regions of Alaska from Ketchikan to Nome. The interior of Alaska will be served by a Fairbanks station. Dorsey A. Lyon will be in charge of the station. He was formerly professor of mining engineering at the University of Washington and is a specialist in electro-metallurgy. Three Government investigators will assist him. Electro-metallurgical treatment of ores will be the first work taken up by the station. The following year it will include in its experiments many problems of mining, milling and metallurgy. Electric furnaces will soon be installed in the present Mines Building and analytical laboratories, and offices will be established in the former Women's League Building.

The European war has temporarily held up plans for an aërodynamics laboratory at the University of Washington. An aërodynamic balance, which is the central instrument in the needed equipment, is not now obtainable. The Cambridge Instrument Co., of Cambridge, England, which has manufactured the few balances in use, is spending all its time in the manufacture of war munitions. An attempt will be made to bring the plans to America for construction. The study of aëronautics became possible at the university when W. E. Boeing, a Seattle capitalist and aëroplane enthusiast, gave the school an endowment to be used in building a laboratory. The present intention is to develop only the theoretical side, but it is hoped to have the Federal Government establish an aviation station close by.

Short winter courses in logging, lumbering and forestry will be given for the ninth time at the University of Washington, Jan. 3 to Mar. 30, 1917. This work is designed for men engaged in forestry and lumbering, who desire to increase their usefulness, and for those men who desire to enter these industries. There will be special courses for forest rangers and guards, loggers, lumber salesmen, architects, engineers and timber inspectors. It is not attempted to make a full-fledged logging engineer or forest ranger in these three months, but the men are given a sufficient foundation so that they can carry forward further work in these fields. A number of lectures and demonstrations will be given by men from lumber companies and the United States Forest Service.

University of Illinois

The new $250,000 Ceramic Engineering Building of the University of Illinois was dedicated Dec. 6 and 7. As shown in the accompanying view, this is a three-story structure covering an area 67x189 ft. It is built of materials that are representative of the ceramic arts, such as high-grade brick, tile, terra cotta, cement and gypsum products. Its laboratories are equipped with the latest types of apparatus needed for instruction and research in the manufacture of stoneware, china, brick, tile, sewer pipe, terra cotta, cements, glassware, sanitary ware, electrical and thermal insulating materials and other ceramic products.

Among the addresses at the dedication sessions are to be noted: "Ceramic Resources of America," by S. W. Stratton, Director of the United States Bureau of Standards, "Science in the Development of Portland Cement Industries," by J. P. Beck, Manager of the Portland Cement Association; "The Manufacturers' Dependence on Ceramic Engineering," by W. D. Gates, President of the American Terra Cotta and Ceramic Co.; "Ceramic Materials in Highway Construction," by W. W. Marr, Chief Highway Engineer of Illinois; "Ceramic Products as Structural Materials," by H. J. Burt, Structural Engineer; "Use of Ceramic Products in the Artistic Embellishment of Buildings," by Claude Bragdon, Architect.

NEW CERAMIC ENGINEERING BUILDING, UNIVERSITY OF ILLINOIS

NOTES

The Lower Otay Dam Bond Election, at San Diego, Calif., is to be reheld, through the medium of initiative petitions. As noted in "Engineering News," Nov. 30, 1916, p. 1057, the bond issue failed to carry in election of Nov. 17 because of the simultaneous submitting of another question. At first it was thought that the courts would be called in to validate the issue but it has since been decided to hold a new election.

East River Tunnel Holed Through—Of the four tunnels for the New York Rapid Transit System, the north tube of the one farthest advanced—between Old Slip, Manhattan, and Clark St., Brooklyn—was holed through at 10 a.m. on Nov. 28. Progress on these tunnels to Nov. 13 was given in "Engineering News" of Nov. 16. On Nov. 13 the two headings of the north tube of the tunnel mentioned were 190 ft. apart, in solid rock, and it was expected that they would meet about Dec. 1. At that time the headings of the south tube of this tunnel were 300 ft. apart.

The City Manager Plan for Cleveland, Ohio, is to be considered by a large committee. The Cleveland Real Estate Board has asked 65 local civic organizations to appoint representatives on the committee. The Cleveland Engineering Society has appointed a committee of three to consider this subject, two of whom will be delegated to attend a general conference on Dec. 15. The three men are: Chairman, Dr. C. S. Howe, president of Case School of Applied Science; F. F. Prentiss, first vice-president Cleveland Twist Drill Co., and Walter P. Rice, president Walter P. Rice Engineering Co.

Indictments for Criminal Negligence in the construction of the concrete building at 64th St. and Third Ave. in New York City, has been brought in against George G. Wilson, of the firm of general contractors for the building, and John Mahon, foreman in charge of the work on the top floor where the collapse occurred. The fall of this floor was reported in "Engineering News," Nov. 30, 1916, p. 1050. It is understood that the contractor denies that the supports under the floor were removed just prior to the collapse but admits that the forms may have been in process of removal and the struts being replaced under the stripped ceiling. The coroners inquest will be held Dec. 11 at the Municipal Building, New York City.

A Water Conservation Committee to study the subject and draft a bill for the conservation of the waters of Pennsylvania has been created as a result of a recent conference at Harrisburg. At the request of the governor, the chairmanship of the committee will be held by Dr. Samuel G. Dixon, commissioner of health. Dr. Dixon has announced the following other members of the committee: Gifford Pinchot, president National Conservation Association; Dr. Henry S. Drinker, president Lehigh University; William H. Keller, deputy attorney general; John B. Eichenauer, member Pittsburgh Flood Commission; George S. Webster, director Philadelphia wharves, docks and ferries; Prof. Edgar Marburg, professor of engineering, University of Pennsylvania; S. B. Elliot, member State Forestry Commission; J. A. Wells, vice-president and chief engineer Pennsylvania Water and Power Co. Other names will be added to the committee, which is expected to give particular attention to industrial wastes.

The United States Reclamation Service, according to the annual report of Secretary of the Interior, Franklin K. Lane, supplied water for irrigation last year to 857,000 acres of land, of which 800,000 were used for crops and produced an estimated value of $19,000,000. The cultivated acreage of the reclamation projects now exceeds the entire cultivated acreage of Delaware or Nevada, and the value of the crops produced on these projects exceeds the value of the crops of New Hampshire or Utah. The forty storage reservoirs on the reclamation work have a combined capacity of 9,000,000 acre-ft., sufficient water to cover the entire States of Massachusetts and Connecticut a foot deep There are on the projects 10,000 mi. of canals, flumes, tunnels and other conduits, and 75,000 structures of all sorts. During the year, construction work was carried on on 24 reclamation projects, 10 of which were finally completed so that public notices were issued opening the land to entry and water service. During the year the Service built 700 mi of canals, 80 mi of drains, 50 mi. of pipe line, 66 mi. of roads, 7,200 canal structures 600 bridges, 650 culverts and excavated about 10,000,000 cu.yd. of earth and rock. While a greater area of the reclamation projects was cultivated than ever before, settlement is still far behind the work of construction. The Reclamation Service is prepared to supply water to 1,680,726 acres, while only 857,000 were actually irrigated last year.

PERSONALS

Horace N. Trumbull has been appointed Advertising Manager of the S K F Ball Bearing Co., Hartford, Conn.

Harry M. Pierce has been appointed Chief Engineer of the E. I. du Pont de Nemours & Co., succeeding the late Maj William G. Ramsay.

Thomas E. Jeffries, United States Assistant Engineer in charge of the Kanawha County work, with offices at Charleston, W. Va., has resigned.

E. K. Clarke, formerly with the bridge department of the Michigan Central R.R., is now Construction Engineer of the two Detroit (Mich.) plants of the Timken Detroit Axle Co.

H. S. Wilder, of Houston, Tex., has been appointed Highway Engineer of Houston County, the county commissioners of which have recently authorized $110,000 for road improvement.

James D. Callery has resigned as President of the Pittsburgh (Penn.) Railways Co. He will be succeeded on Jan. 1, 1917, by **Summer L. Tone,** Vice-President of the Duquesne Light Co.

W. M. Jacklin, Supervisor of Roadway of the Canadian Northern Ry. at Hornepayne, Ont., has been appointed Inspector of Maintenance-of-Way of the lines east of Port Arthur, Ont., with office at Toronto, Ont.

Charles S. Butts has been appointed Engineer of Construction of the new municipal dock at North Market St., St. Louis, Mo. He was recently Traffic Engineer of the Department of Public Utilities. The salary of the new position is $2,400 per annum.

Joseph E. Kuhn, Colonel, Corps of Engineers, U. S. A., who has been Military Attaché to the American Embassy at Berlin since December, 1914, has been recalled. He was appointed Military Observer with the German armies, but according to newspaper accounts he has had very little opportunity of observing.

Albert J. Himes, M. Am. Soc. C. E., has been relieved of his duties in charge of grade-crossing elimination work on the New York, Chicago & St. Louis R.R. in order to devote his whole time to valuation work, under the title of Valuation Engineer. **W. J. Bergen,** First Assistant to the Chief Engineer, has been appointed Engineer of Grade Crossing Elimination.

Cornelius Vanderbilt, who has been Divisional Inspector of the New York National Guard with the rank of Major, has been commissioned Colonel of the 22nd New York Engineer Regiment, one battalion of which is still on the Mexican border. Colonel Vanderbilt is a graduate in mechanical engineering of Sheffield Scientific School, Yale University, and for a time was interested in engineering work. He is now a capitalist and an officer and director of many corporations.

Raymond W. Parlin, Assoc. M. Am. Soc. C. E., Staff-Investigator of the Bureau of Municipal Research, New York City, has been appointed Deputy Commissioner of the Department of Street Cleaning of New York City, under J. T. Fetherston, Commissioner. Mr. Parlin is a graduate of the Massachusetts Institute of Technology in chemical and sanitary engineering. He recently made a comprehensive study of street cleaning, some of the results of which were presented in a paper read at the Newark convention of the American Society of Municipal Improvements.

OBITUARY

Albert C. Warren, Secretary of the Warren Brothers Co., Boston, Mass., died Nov 10. He was born Mar 18, 1852.

Frederick Boldt, for many years prominent in the steel industry as founder and President of the Boldt Steel Casting Co., New Castle, Del., died Dec. 1, at his home in Chester, Penn.

Charles Wiley, Vice-President of John Wiley & Sons, the well-known publishers of engineering books, died Dec 3 at his home in East Orange, N. J. He was in his 83rd year.

J. E. Dietrick, of Dietrick & Guth, Architects, Omaha, Neb., died Nov. 6, aged 63 years. He went to Nebraska 42 years ago as a civil engineer. He was first employed by the Chicago, Burlington & Quincy R.R. and the Union Pacific R.R.

David Benjamin, head of the Pennsylvania Quarrying, Stripping and Contracting Co., and President of the Benjamin Iron and Steel Works, Hazleton, Penn., was killed on Nov. 28 by falling in front of the dinkey locomotive on which he was riding.

Frederick J. H. Merrill, M. Am. Inst. M. E., a mining engineer of Los Angeles, Calif., and a former State Geologist of New York, died Nov. 29 in his 55th year. He was born in New York City and was graduated from the Columbia School of Mines. For several years he was connected with the Geological Survey of New Jersey and later with that of New York.

Daniel O'Connell, head of the firm of Daniel O'Connell's Sons, General Contractors, of Holyoke, Mass., died Nov. 23. He was one of the last survivors of that race of Irish contractors whose careers started as day laborers in the period before the Civil War, when Irish labor was commonest on all construction work. He was born in Ireland in 1832, and his parents emigrated to this country in 1847. At 15 years of age he was a water-boy on the first Connecticut River dam built by the Hadley Falls Co. Later he was a railway laborer. From this he graduated into taking small contracts on his own account, and out of this grew a firm of general contractors which has executed construction work throughout central New England.

Micajah Terrill Burgess, a pioneer Western railway engineer died at his home in Salt Lake City, Nov. 23. He served on the engineering staff under the late Gen. Grenville M. Dodge, Chief Engineer of the Union Pacific R.R. during its construction period. Following the completion of the Union Pacific he worked as a surveyor with office at Salt Lake City, and he also served as chief clerk in the office of the Surveyor General of Utah. Subsequently he was engaged as Engineer of Location and Engineer of Construction on many early Western railway projects. Shortly after the San Francisco fire and earthquake in 1906, he established his headquarters as a surveyor in that city. A few years later he returned to Utah and retired as a farmer.

William E. Craighill, Colonel, Corps of Engineers, U. S. A., whose death was briefly noted in these columns last week, was born in Maryland, Dec. 20, 1863. He was a son of Brig.-Gen. William P. Craighill, former Chief of Engineers of the United States Army. After being graduated from the United States Military Academy at West Point in 1885 as second in a class of 39 cadets, he was commissioned Second-Lieutenant in the Corps of Engineers. During the War with Spain in 1898 he was offered and declined a commission as Major and Chief Engineer of Volunteers. In 1899 he was commissioned Major in the 40th Infantry and went to the Philippine Islands. From there he was sent to China during the Boxer uprising in 1900, being on the staff of the commanding general. Later he was reinstated in the Corps of Engineers and at the time of his death was in charge of the Boston district, Northeast division.

Harold Parker, M. Am. Soc. C. E., Vice-President of the Hassam Paving Co., Worcester, Mass., and former Chairman of the Massachusetts State Highway Commission, died Nov. 29 at his home in Lancaster, Mass., aged 62 years. He was born in Charlestown, June 17, 1854, and was a lineal descendent of the Massachusetts Pilgrims. He was educated at Phillips Exeter Academy and Harvard College. His engineering experience began at the Pennsylvania Steel Works, where he served for a time as a foreman. Later he returned to Massachusetts and with F. W. Bateman, of Clinton, organized the firm of Parker & Bateman, Civil Engineers, of which firm he continued to be a member to the time of his death. He was appointed a member of the Massachusetts State Highway Commission in 1900. Later he was made Chairman of the commission, in which capacity he served until 1911, when he resigned to become Vice-President of the Hassam Paving Co. He also served as Chairman of the Wachusett Mountain State Reservation Commission and as Chairman of the State Forest Commission. Mr. Parker was a member of the advisory board appointed in 1913 by Governor Dix to investigate and report upon the New York State Highway Department. He was a Past-President of the American Road Builders Association and of the Massachusetts Highway Association.

ENGINEERING SOCIETIES

NORTHWESTERN ROAD CONGRESS.
Dec. 7-8. In Chicago. Secy., J. L. Long, Moline, Ill.

PORTLAND CEMENT ASSOCIATION.
Dec. 11-13. Annual meeting in New York City. Assistant to General Manager, A. H. Ogle, Chicago, Ill.

OKLAHOMA SOCIETY OF ENGINEERS.
Dec. 27-28. Annual meeting in Tulsa. Secy., H. G. Hinckley, Oklahoma City.

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS.
Dec. 27-29. Annual meeting at Chicago. Secy., D. K. Shedd, Ames, Iowa.

COMPRESSED GAS MANUFACTURERS' ASSOCIATION.
Jan. 15. Fourth annual meeting in New York City. Secy., O. S. King, 120 Broadway, New York.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
Jan. 17-18. Annual meeting at Society House, New York City. Secy., Charles Warren Hunt, New York.

AMERICAN ROAD BUILDERS' ASSOCIATION.
Feb. 5-9. Eighth National Good Roads Show, in Boston, Mass. Secy., E. L. Powers, 150 Nassau St., New York City.

TENTH CHICAGO CEMENT SHOW.
Feb. 7-15. In Chicago. Under management of Cement Products Exhibition Co., 210 South La Salle St., Chicago.

AMERICAN CONCRETE INSTITUTE.
Feb. 8-10. In Chicago at La Salle. Secy., H. D. Hynds, 30 Broad St., N. Y.

NATIONAL BUILDERS' SUPPLY ASSOCIATION.
Feb. 12-13. In Chicago at Sherman. Secy., L. F. Desmond, 1211 Chamber of Commerce, Chicago.

SOUTHWESTERN CONCRETE ASSOCIATION.
Feb. 19-24. Southwestern Concrete Show in Kansas City, Mo. Address Chas. A. Stevenson, 1413 W. 10th St., Kansas City.

The County Road Engineers' Association of Kentucky is to hold a meeting Jan. 17 to 20 at Bowling Green, Ky.

The Electric Power Club held its seventh semi-annual meeting at Hot Springs, Va., Nov. 15 to 18, the attendance comprising about seventy men, representing thirty manufacturers of electric motors, generators, transformers and industrial control apparatus.

The National Fire Protection Association will hold its next annual meeting May 8 to 10 in Washington, D. C. The winter meeting of the executive committee has been called for Dec. 15 by Chairman F. J. T. Stewart. The secretary is Franklin H. Wentworth, 87 Milk St., Boston.

The Cleveland Engineering Society on Nov. 21 listened to talks by F. H. Newell and Hunter McDonald and to a communication from Isham Randolph. The three speakers with M. L. Cooke were in Cleveland to attend a meeting of the plan-and-program sub-committee of the National Conference on Coöperation. Mr. Randolph's contribution was a brief autobiography limited to the earlier years of his career, to bring out the importance of the help and guidance obtained by the young engineer from his older professional brothers. Professor Newell sketched some of the phases of engineering coöperation. Mr. McDonald gave an advance summary of the elaborate printed argument which is being prepared at Nashville by a committee of the Engineering Association of the South to bring about the location of the government nitrate plant at Muscle Shoals on the Tennessee River.

The American Institute of Mining Engineers—The Committee on Nominations submits the following names as its nominees for officers in 1917: President, Sidney J. Jennings, New York; vice-presidents, Walter H. Aldridge, New York; Mark L. Requa, San Francisco; for directors, J. E. Johnson, Jr., New York; Allen H. Rogers, Boston; Howard N. Eavenson, West Virginia; Robert M. Raymond, New York; Willet G. Miller, Canada. The report of the Nominating Committee goes on to say that many letters have been received regarding the presidential nomination, and that some of the letters indicate that the authors feel that the nomination of president should be left entirely to the Committee on Nominations without any effort by the members at large to influence them, while others feel that the nominations are largely controlled by small groups and that the members at large can have little influence. As a result of this influence the majority of the Committee suggests that the method of making nominations be changed so that at least two candidates for the various offices be nominated, and suggests that the directors appoint a committee to investigate this question thoroughly.

Southwestern Engineering Society—A. F. Barnes, Dean of Engineering, of the New Mexico College of Agriculture and Mechanic Arts, State College, N. M., has been endeavoring to organize a Southwestern Engineering Society. Letters have been received from prominent engineers in New Mexico, Arizona and Texas expressing the need of such an organization. Among the men who have promised their support are Dean G. M. Butler, University of Arizona, Tucson; Dean S. H. Worrell, Texas School of Mines, El Paso; Professor Brenneman, University of New Mexico, Albuquerque; Samuel I. Bousman, Engineer for the Chino Copper Co., Hurley, N. M.; H. L. Stevens, consulting refrigeration engineer, El Paso; E. H. Baldwin, El Paso, Project Manager of the Elephant Butte

Dam; and S. O. Andros, Albuquerque, "Chairman of the New Mexico State Directors, Naval Consulting Board." The object of this organization will be to promote the science of engineering in the Southwest. The principle means for this purpose shall be: First, the holding of meetings for the reading and discussion of professional papers especially upon such questions as are peculiar to this region; second, to give opportunity for social intercourse and thus establish a common interest in the welfare of the engineering profession. Admission to this society will no doubt not only be open to practicing engineers, but opportunity to join will be given to any person so connected with engineering as to qualify him to coöperate with engineers in the advancement of professional knowledge. It is planned in a short time to call a meeting of those engineers that have shown interest in the matter and at such a time draw up tentative plans and program for a general meeting to be held at a suitable place at which time final organization can be effected.—A. F. Barnes.

Appliances and Materials

Sound-Absorbing Stone

Another sound-absorbing stone veneer has been put on the market—this time by the H. W. Johns-Manville Co., of New York City. It bears the trade name "Akoustolith" and is made under the patents of R. Guastavino and W. C. Sabine, who, it will be recalled, have developed a sound-absorbing dome tile. The new veneer has an absorbing capacity of from 38 to 57%, at the standard pitch of violin C, and is second only to hair felt. It is a molded material of concrete nature and is applied over any masonry surface. It can be made in tile or brick form or cast into ornamental pilasters, moldings, etc. It has about a third the weight of stone and is made in a variety of colors.

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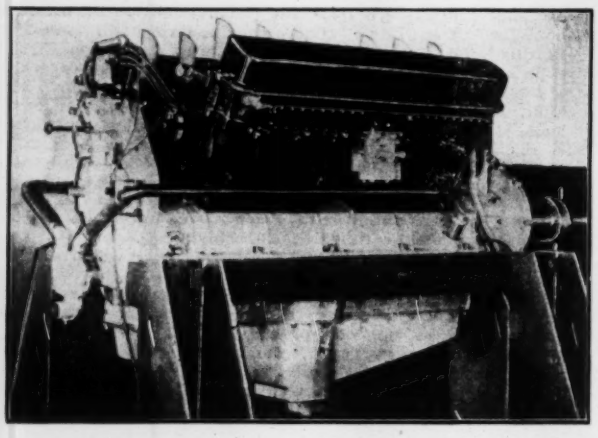
A 300-Hp. Aëronautic Motor

A 300-hp. aëronautic gasoline engine, the largest ever attempted, has been completed by Frank H. Trego, Chief Engineer of the Knox Motors Co., Springfield, Mass., in response to the demand voiced by U. S. Naval Advisory Board and the Navy Air Service. A year's study was spent on the design. The first motor, weighing 1,400 lb. complete with electric starting and ignition system, was recently run on a dynamometer at Springfield under full load for eight hours.

The general arrangement is that of a 12-cylinder 60° V-type. The crank case is of a special aluminum alloy, one piece each for the upper and lower halves. For support, a shelf running the full length of the case on each side takes the place of legs. The motor will enter a frame 15 in. wide—17 in. between holding-bolt centers. The cylinders are of aluminum alloy and have ⅛-in. cast-iron liners. They are cast in blocks of three and are open at both ends. Total piston displacement is 1,488.5 cu.in. Water jackets extend below the stroke. Cylinder heads are of aluminum alloy, cast in blocks of six. Each head carries four cast-iron valve seats, cast in, with each seat practically surrounded by the head water jacket.

Cam shafts and rocker arms are in the head; each shaft has eight bearings, and the rockers are supported above. All head mechanism is under forced-feed lubrication with drainage to the crank case. The head has a protecting cover.



TREGO 300-HP. AERONAUTIC MOTOR

One end of the case supports a large alloy-casting support for the propeller shaft and starting motor. On the other end of the motor are the supports and housing for timing gears, water and air pumps, ignition apparatus and lighting generator. There is nothing on the outer sides but the carburetors. The main shaft is of chrome-nickel steel and has three bearings—babbitt in bronze shells. Connecting-rods are drop forgings; pistons are of aluminum alloy. The propeller shaft (3⅜ in. bored to ½ walls) is carried on heavy double-row ball bearings with double ball thrust bearings. Gears between the motor and propeller shaft allow various speed ratios, the preliminary tests being made with 1,600 to 1,140 r.p.m.

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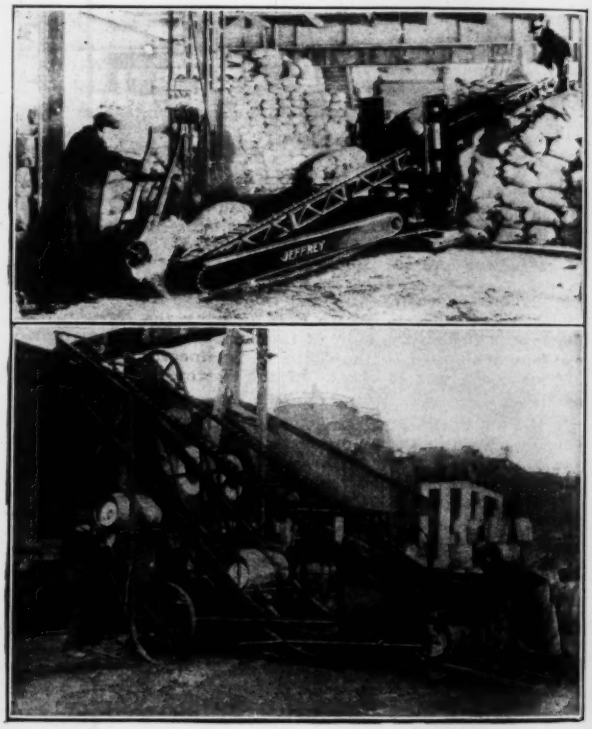
New Line of Portable Conveyors and Stackers

During the past year, the Jeffrey Manufacturing Co., of Columbus, Ohio, has completed the development and is now marketing a new line of portable conveyors and stacking machines. A combination of light weight and heavy duty is claimed secured. The conveyors are of the endless-belt type and are built in 20-ft. framed sections (each with its own belt) mounted on ball-bearing casters and with guarded chain belts connecting the end sprockets. A 5-hp. motor is sufficient for seven sections, the driving section being placed anywhere in the string. The belts are usually 18 in. wide and travel at a speed of 125 ft. per min. The capacity of such a conveyor is 1,500 80-lb. packages per hour.

There is a barrel loader, made up of a pair of triangular steel trusses, moved about like a balanced two-wheeled baggage truck, in which a pair of endless chains with crossbars engage the barrels at the ground level and roll them up an inclined track and let them off at an upper (8 ft.) or a middle (5 ft.) level according as the track may be set. A



PORTABLE BARREL LOADER AND BAG STACKER

2-hp. motor drives one of these machines and with it two men can handle up to 180 bbl. per hr. This loader weighs 3,200 lb. and costs about $700.

A portable stacker is also included in the new equipment. This is of the full-apron type, for bags and miscellaneous freight, and has been built for up to 42x52-in. by 5-ft. 600-lb. bags. The loading boom is 24½ ft. long; the lower end is pivoted on a latticed steel frame carried by ball-bearing casters, and the upper end is lifted (to 14½ ft. maximum height) by hand-winch cables running to under-struts beneath the boom forward of the middle. The boom supports 6x12-in. wood flights mounted on two roller chains. A 2-hp. motor drives the stacker, which weighs about 2,700 lb. and costs about $750.